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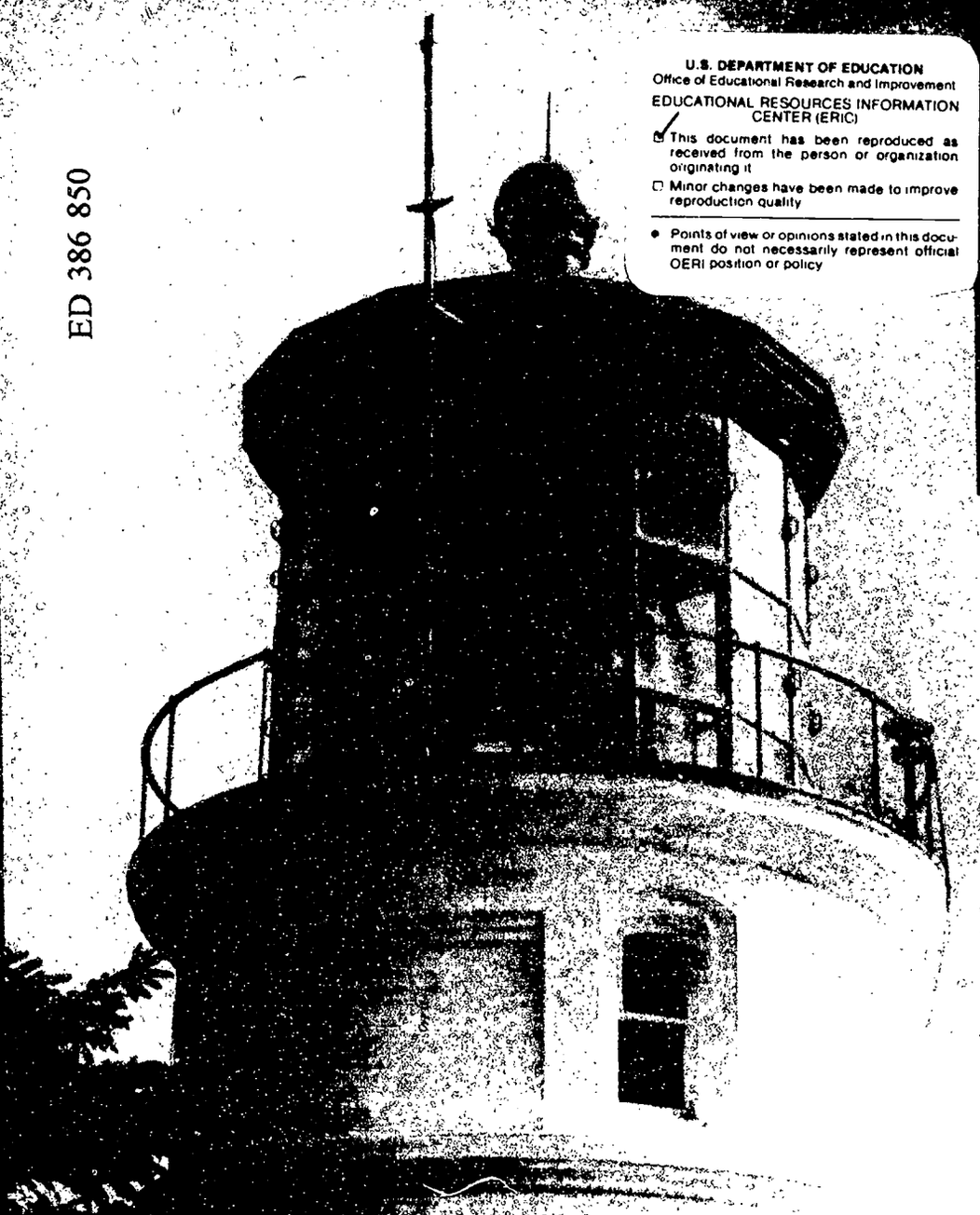
ABSTRACT

Research findings and descriptive articles pertaining to media, materials, and technology (MMT) which provide access to education of deaf and hard of hearing children from early childhood through eighth grade are reviewed and summarized. An introduction discusses the purpose and goal of the study; the target population; characteristics of deaf and hard of hearing children; degree of hearing loss; age of onset; language of the home; sign skills of teachers; types of educational programs and communication methodologies (oralism, total communication, bilingual/bicultural programs, cued speech); and educational placement alternatives (self-contained classes, partial mainstreaming, social mainstreaming, and full mainstreaming). The report then synthesizes the research in five chapters on the following areas: (1) assistive technology for education, including listening aids, visually based aids, and computer systems; (2) receptive skill development (audition and speech reading); (3) English language development and refinement; (4) media, materials, and technology for the development and educational use of American Sign Language; and (5) speech development. For each area, existing materials, developmental needs, and criteria and guidelines for optimal tools are discussed. Limitations of the research are also identified. An executive summary is included. (Individual chapters contain references.) (DB)



National Center to Improve the Tools of Educators

College of Education
University of Oregon

Research Synthesis on Design of Effective Media, Materials and Technology for Deaf and Hard-of-Hearing Students

Technical Report No. 1 produced for the National Center to Improve the Tools of Educators, University of Oregon

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Research Synthesis on Design of Effective Media, Materials and Technology for Deaf and Hard-of-Hearing Students

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December 29, 1993

National Center to Improve the Quality of Technology,
Media and Materials: Research Synthesis

Design of effective media, materials and technology for deaf and hard-of-hearing students

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National Center to Improve the Quality of Technology,

Media and Materials: Research Synthesis

Design of effective media, materials and technology

for deaf and hard-of-hearing students

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Executive Summary

The purpose of this research synthesis is to review and summarize research findings and descriptive articles pertaining to media, materials and technology (MMT) which provide access to education of deaf and hard-of-hearing children from early childhood through eighth grade. The goal of the research synthesis is to use research findings and expert opinion to present guidelines and criteria for what constitutes optimal tools for this purpose.

The research synthesis deals with the following areas:

1. Assistive technology for education, including listening, visually based, and computer systems
2. English language development and enhancement
3. Development and educational use of American Sign Language (ASL)
4. Speech development
5. Receptive skill development (audition and speechreading)
6. Communication strategies
7. Orientation and training to use hearing aids, assistive listening devices and cochlear implants.

For each area, criteria and guidelines for optimal tools, critique of existing materials, and developmental needs are discussed. Limitations and restrictions of the research are also discussed in each section.

The research synthesis does not include media, materials and technology pertaining to parent education, use of interpreters, and curricular areas such as math, reading, social studies, science, music, art, health education, drug and sex education. Media, materials and technology for deaf adult learners, postsecondary instruction, vocational education, transitional programs, and adolescent substance abuse programs are not included. Materials to develop manually coded English and Cued Speech are also not included.

The target population includes all deaf and hard-of-hearing children from preschool through grade 8 with prelingual and later onset of hearing loss ranging from mild to profound. The document is relevant to manual, oral, English and ASL communicators and applicable to oral, total communication, bilingual/bicultural (ASL), Cued Speech, self contained and mainstreamed programs.

The research syntheses were based on computer searches of data bases covering the period from January, 1981 to June, 1993, including CATS, ERIC, Dissertation Abstracts, Washington Research Library Consortium, Periodical Indexes, and Newspaper Abstracts. Computer and manual searches of the following periodicals were conducted: Volta Review, American Annals of the Deaf, Journal of the Academy of Rehabilitative Audiology, Gallaudet Deafness Collection, Perspectives in Education and Deafness, Educational Technology, Educational Technology Research and Development, Computer and Education Journal, The Computer Resource Quarterly for People with Disabilities, and other selected curricula and books. In addition to these sources, the syntheses draw from the research and clinical experience of the authors as well as contact with selected individuals, currently working with deaf children.

ASSISTIVE TECHNOLOGY FOR EDUCATION

The following general considerations for development of quality visual or auditory MMT for deaf and hard-of-hearing children appeared in the few documents that were found:

1. Information should be presented in picture or graphic form whenever feasible. Text should be kept to a minimum.
2. MMT should be developed that is specifically for deaf and hard-of-hearing children, rather than adapting technology developed for hearing children.
3. MMT that schools can afford should be developed.

Visual Technology

Apple microcomputers and associated software are used in the vast majority of programs for deaf and hard-of-hearing children. Very few software programs, however, are designed specifically for deaf or hard-of-hearing children and those that are, are not necessarily more effective that adapted programs. Continued development of educational software programs for deaf and hard-of-hearing children is needed, with more use of IBM computers. Captioning systems need to be more user-friendly, with more open-caption software programs designed for use by students. Teachers report that successful software is characterized by the following features:

1. A game-like format with high-resolution graphic displays to motivate students
2. Graphic reinforcement for correct answers rather than word displays (eg. clown jumping and clapping)
3. Positive feedback to correct mistakes (eg. "try again")
4. Minimum amounts of text
5. All auditory features accompanied by visual components (eg. graphic display)
6. Menu-driven programs should to lessen the need for adult involvement
7. Extensive use of visual prompts
8. Foolproof keying so that hitting the wrong key will not cause the program to re-boot or exit the document
9. Flexibility so that the same program can be used for a variety of subjects and at different levels of difficulty.
10. Modifiability of programs (eg. ability to add specific vocabulary)

Use of computer assisted notetaking as an educational tool for large group applications where notes are being projected onto a screen should be increased. More word processing programs are needed with large font sizes and the ability to change sizes and fonts. User-friendly keyboard expansion software programs, quieter keyboards, quieter overhead projectors, and overhead projectors that work well when the lights are on are also needed.

Increased use of interactive video is desirable. Additional captioned educational videodisc programs should be developed using multimedia environments. Digital equipment

needs to be made available at affordable prices, including tools for creating multimedia captions.

Auditory Technology

Induction loop systems are being used in educational settings, but are limited by spillover problems. Oval Window Audio has developed the 3-D Induction loop system to minimize this problem. Development of such innovative products should continue. Standards for induction loop systems and hearing aid telecoils are needed.

FM systems are the most widely used auditory technology used in education. They should contain the following features:

1. Individual controls for adjusting frequency response and output of system.
2. Auxiliary microphone input capabilities for movie projectors, multiple microphones, and other sources.
3. Binaural reception
4. Easy to see and read low battery indicators
5. A switch allowing for selection of environmental microphone alone or teacher's microphone alone.
6. Directional microphone for the teacher
7. Voice-activated microphone mixing system for multiple speaker situations
8. Ability to switch between carrier frequencies on both receiver and transmitter
9. Automatic recharging and shut-off capabilities when in the storage/charging unit.
10. Ability to operate with a disposable 9-volt as well as a rechargeable battery.

Soundfield amplification systems have been found to be useful in the classroom as supplemental listening systems to enhance the signal/noise ratio. They can be used for hearing, hard-of-hearing, and learning disabled children and are significantly less expensive than individual FM units. However, they cannot guarantee the fidelity provided by the personal FM system, which should be the technology of choice for children with severe to profound hearing loss.

RECEPTIVE SKILL DEVELOPMENT

This synthesis deals with deaf and hard-of-hearing children. Not included are children with central auditory processing disorders, auditory learning disabilities, deaf-blindness or other disabilities in addition to deafness.

Although review of the literature revealed essentially no research data on guidelines and criteria for MMT, there was a considerable amount of discussion based on expert opinion. The following discussion and recommendations are based largely on this expert opinion.

Auditory Skills

Auditory training programs should include activities to develop skills in the following areas: detection, localization, selective attention, memory/sequencing, discrimination of suprasegmental and segmental speech features, closed-set and open-set identification of speech and environmental sounds, comprehension, figure-ground skills, voice monitoring, and use of suprasegmental information.

Both analytic and synthetic activities should be included, but the focus should be on language based activities using real life situations. Auditory training activities should be integrated with language training, speech production and speechreading. Some activities may be unimodal but audiovisual integration should be a priority. Discrimination training, especially activities using non-linguistic materials, should be minimized.

All activities should be interactive, meaningful, intrinsically rewarding, provide for individual adaptation, and allow for expansion and remediation strategies, as needed. Curricula and programs should include assessment procedures and provide individual programming.

All auditory training activities are predicated on the proper use of hearing aids. Therefore, all auditory skills curricula should include hearing aid orientation activities which teach parents and children realistic expectations of their hearing aids, how the hearing aid functions, proper use and care, ability to perform daily visual and listening hearing aid checks, and ability to troubleshoot malfunctions.

Similarly, curricula need to include orientation to assistive listening systems, particularly FM. There is a need to incorporate objectives and activities into school curricula and a need for studies evaluating the benefits of such training.

Although most schools for deaf and hard-of-hearing children have developed auditory skills curricula, several of which have been disseminated, for the most part these curricula use an analytic, bottom-up approach. There is a need for synthetic, language and situation based programs suitable for natural conversational or language experience approaches in the classroom, using materials that are suitable for the language competence and interests of a wide range of children. Simulated or actual real life situations need to be utilized to a much greater extent than currently exists.

Although most auditory skills curricula contain hearing aid orientation objectives and activities, there is a notable absence of orientation and training materials for assistive devices and cochlear implants. Only one comprehensive cochlear implant curriculum for adults (Cochlear Corporation) was found and this is not readily available to schools. Aural rehabilitation is essential to the successful use of the increasing numbers of cochlear implants being fitted to deaf children. Comprehensive training programs incorporating orientation activities, top-down and bottom-up auditory and audiovisual training integrated with speech production activities are needed. Of particular importance are materials to help families and children develop realistic expectations of the benefits of cochlear implants.

Voice telephone and TTY training involve auditory skills, speech production, language skills, communication strategies, use of assistive devices, and informational counseling. Although several curricula have been developed for adults, only one program for elementary school children has been identified. This program does not contain speech production activities nor instruction in use of third party relay systems. Telephone training curricula, in print and interactive video form, are needed for children.

Speechreading and Communication Strategies

Speechreading programs for children should also be primarily language based, using meaningful real life experiences. Speechreading should be integrated with auditory, receptive and expressive communication strategies training. Programs should include training in assertive behavior and conversational strategies. Although several top-down curricula have been developed and disseminated by the Pre-college programs at Gallaudet University, there is need for additional curricula incorporating a synthetic, interactive, integrative focus.

Connective discourse tracking is an excellent activitity for developing speechreading, audiovisual, and communication strategies skills. It can also be used to improve speech intelligibility. There is need for development of age and language appropriate tracking materials for children.

Interactive videodisc technology can be used for auditory skills, speechreading, and communication strategies training. It is interactive, highly motivating, can provide immediate feedback, and can individualize instruction by tailoring stimulus presentation to the child's responses. Tye-Murray and colleagues have developed several videodisc programs for children which contain both analytic (bottom-up) and synthetic (top-down) programs. There is need for additional programs which focus on real life situations. Much of the printed curricular materials, including tracking activities, can be adapted to video technology.

ENGLISH LANGUAGE DEVELOPMENT AND REFINEMENT

In order to effectively use the linguistic code of English, the language learner must have knowledge and expertise in the areas of:

1. Semantics or meaning (eg. vocabulary, figurative or nonliteral language)
2. Syntax and morphology (word order/grammatical information)
3. Phonology (sounds)
4. Pragmatics or the appropriate use of language. This includes the ability to get or give information, use the conventions of conversations such as initiation or termination of a topic of conversation, and provide sufficient information to a conversational partner to assure understanding of the message (taking the perspective of the receiver).

Children learn the various aspects of language through interaction with a primary caretaker through natural play and daily routines. Lack of auditory input provides incomplete access to the form of language and may effect the ease with which pragmatic aspects of English are learned. Children with hearing loss need to be given continuous opportunities to participate and use language through communicative interaction with others in their environment. At the same time, they may need structured assistance in refining specific areas of language.

Materials are reviewed in the synthesis which are representative of the available programs currently used with deaf and hard-of-hearing children. Reading curricula, language materials used for teaching content information, and MMT used for training memory, problem-solving, inferencing, etc. are not included.

The most commonly used materials for parent-infant work are the SKI-HI materials developed at the University of Utah. The program includes screening, referral, diagnosis, psychosocial support for parents, and parental language facilitation skill development in the home. Although longitudinal research in the efficacy of this program is in process, no published research is available. The results of needed programmatic research in the field of language development of deaf children should play an active role in the development of new materials.

Programs for school-age deaf and hard-of-hearing children tend to focus on a structural approach to written English in contrast to the focus on natural verbal language at the preschool level. Teacher emphasize specific skill areas, particularly syntax and grammar, at the school level. The Apple Tree program is reported to be widely used as an instructional language guide. Few programs in the areas of vocabulary and figurative language have been designed for children with hearing loss.

Programs to teach semantics are needed which are flexible in terms of complexity, cultural differences, interest level, and current experience. Children should not be expected to master many different figurative expressions in a short period of time.

Computer assisted instruction (CAI) is being used for drill, practice and tutorials. In addition, it can be used for simulation of real life situations, problem solving activities, exploration and discovery activities, and instructional games which sharpen note-taking abilities, ability to follow directions, hypothesis testing, and cause-effect relationships. Videodisc technology and hypermedia learning which uses materials that access multiple senses, facilitate language programming. Several interactive computerized programs for children loss are reviewed:

1. ALPHA system which emphasizes exploratory learning. The child is able to initiate communication with a teacher about a topic of interest.
2. Programs at the California School for the Deaf at Riverside designed to improve students' understanding of language structures, improve skills in sequencing events, and build vocabulary.
3. The ENFI (Electronic Networks for Interaction) gives deaf students at Gallaudet opportunities to use written English in different ways by engaging in real-time computer dialogues.

Following are recommendations for future development of MMT for English language development of children with hearing loss:

1. There is little definition in the literature nor understanding of the best way to develop English in deaf and hard of hearing children. Therefore, program developers need to work closely with researchers to identify the most important elements and ways to use MMT.
2. Programs need to identify the model on which they are based.
3. Evaluation procedures need to be built into programs.
4. Programs should be broad in scope rather than limited to only one aspect of language.
5. Focus should be on a conversational-interactive-functional approach in which children are involved in dynamic communication.
6. Age and interest-appropriate materials are needed, including materials representing experiences specific to deaf children and reflecting cultural differences. Materials need to reflect a range of developmental levels.
7. Materials need to be integrated into the regular curriculum and classroom activities.
8. MMT for children with hearing loss should rely heavily on visual input.
9. Programmed instruction at the written level should maximize interaction. Network based programs facilitate social interaction.
10. Most technological programs are being used with school-age children. MMT are needed for younger children.

11. Programs should be designed to be modifiable over time to reflect new insights into language development.

MEDIA, MATERIALS, AND TECHNOLOGY FOR THE DEVELOPMENT OF ASL

This section reviews existing media, materials and technology related to the teaching of ASL to children with hearing loss. MMT related to English signing systems, Cued Speech, and the use of sign language interpreters in education are not included.

There are materials that teach ASL to non-native users as a second language and other materials that teach English as a second language to students already proficient in ASL. However, there is a dearth of curricula, media, materials and technology for developing ASL as a first language. The document "Unlocking the Curriculum: Principles for Achieving Access in Deaf Education" proposes a model for teaching ASL as a first language during early childhood and later teaching English as a second language in written form. Early communication occurs exclusively through sign language, with literacy in English occurring during later childhood. Students learn to speak and speechread at the time they develop English literacy. MMT that are recommended as part of this model include:

1. Videotapes for sign language training directed toward both parents and children
2. Print materials for reading readiness, reading and writing
3. Companion print and captioned video materials to accompany standard grade level content sources
4. Video materials on deaf people and their way of life
5. Print and non-print materials for teaching English as a second language
6. Print and non-print materials for teaching ASL arts
7. Interactive videodisc-computer technology for the provision of comparative ASL and English passages.

Although three bilingual-bicultural programs (ASL as a first language) exist in the United States, it is too early to tell if they are proving any more successful than other types of educational programming. More program evaluation is needed.

The most promising materials to date are those using interactive video learning and videotape series that attempt to develop all aspects of ASL, not merely lists of vocabulary.

The most effective materials are those that encourage interaction with users of ASL, either between adult language users and deaf children or between deaf children themselves.

Materials and technology that encourage family members to interact with adult language models are needed. Videotapes and interactive computer programs for home use should focus on whole language learning rather than only vocabulary, and should provide information to hearing family members about how to get a deaf child's attention, how to interact visually, and how to recognize stages of ASL acquisition in their children. The use of interactive video-conferencing technologies may make it possible for deaf children to acquire ASL from native signers more effectively.

SPEECH PRODUCTION TEACHING

Sensory information plays a key role in speech acquisition by permitting development of models and providing feedback to mediate speech change. For many deaf children, audition is too limited to be adequate as the primary source of feedback; they require alternate sensory information. Although studies examining the overall efficacy of existing computer-based speech teaching systems suggest their use contributes to speech improvement, more studies are needed to compare their use to more traditional approaches (eg. Ling).

A promising aspect of computer-based systems is their potential for independent drill and practice. This is important for many school programs because of reduced class time for speech development activities. While home use is an important application of these systems, safeguards must be taken to limit development of inappropriate speech behaviors resulting from drill and practice of incorrect patterns.

Tactile devices have been found useful for teaching prosodic production features such as intonation. Additional wearable devices need to be developed and evaluated as aids to speech monitoring.

Existing curricular texts, media, and supportive materials based on the Ling model need revision to incorporate our current understanding of speech learning by deaf children. Alternative or modified approaches to speech teaching with curricula, particularly those based on more top-down, synthetic, language-based teaching strategies, need to be described and developed.

Current technologies focus primarily on suprasegmentals and vowel production or on elicitation, automation, and some degree of generalization of targets. Speech teaching devices are needed that focus on consonant production and facilitation of linguistic use. Current systems are limited in the availability of cues used for development of carryover of skills taught; greater flexibility in presentation of cues is needed.

Results of needed basic research on the value of different forms of feedback need to be incorporated in speech training devices. Although provision of feedback is the primary feature of many devices, in most cases they lack flexibility in controlling feedback parameters. Basic evaluation of tactile and visual feedback devices is needed to determine for which speech skill areas each type of system is most useful.

More clinical efficacy studies on commonly-used commercially available systems are needed, including efficacy of programs using combinations of existing technologies. Such studies should be child-centered rather than device-centered, since speech production training needs vary with individual children.

National Center to Improve the Quality of Technology, Media and Materials: Research Synthesis

Design of effective media, materials and technology for deaf and hard-of-hearing students

Introduction

Hearing loss of any degree can impact oral and written language skills, with consequent social, emotional, and academic difficulties. Most deaf and hard of hearing children have intact nervous systems and cognitive abilities. It is possible to lessen the effects of hearing loss with early and appropriate intervention in the following areas: language development (English and/or American Sign Language); hearing aids and assistive technology with proper orientation to their use; speech development; auditory skill development; speechreading; and use of communication strategies. Communication strategies are behaviors that people can use to prevent anticipated communication difficulties or resolve communication breakdown when it occurs. Although development of normal English language skills and subsequent academic success are difficult tasks for most deaf and hard of hearing children, these goals can be facilitated if early appropriatate intervention occurs (Lenneberg and Lenneberg, 1975; Ling and Ling, 1978) The Education of All Handicapped Children Act (P.L. 94-142) and the amendments of 1986 (P.L. 99-457) mandate basic levels of educational and management services for all children with special needs from birth through age 21.

Purpose and Goal of Research Synthesis

The purpose of this research synthesis is to review and summarize research findings and descriptive articles pertaining to media, materials and technology (MMT) which provide access to education of deaf and hard of hearing children starting in early childhood. The

synthesis has been commissioned by staff of the National Center to Improve the Tools of Educators (NCITE).

The goal of the research synthesis is to use research findings and expert opinion to present guidelines and criteria for what constitutes optimal tools to provide access to education for deaf and hard of hearing children. Hopefully this information will provide the basis for development and/or improvement of such tools so that academic and social education becomes more accessible for children with hearing loss.

In addition to guidelines and criteria, the synthesis discusses how well existing MMT meet guidelines, how they might be modified, limitations of the state of the art, and areas in which new development is needed.

The research synthesis deals with the following areas as they pertain to deaf and hard of hearing children:

1. Review of assistive technology for education, including listening, visually based, and computer systems.
2. English language development and enhancement
3. Development and educational use of American Sign Language (ASL)
4. Speech development
5. Receptive skill development (audition and speechreading)
6. Communication strategies
7. Orientation and training to use hearing aids, assistive listening devices, and cochlear implants.

For each area, criteria and guidelines for optimal tools, critique of existing materials, and developmental needs are discussed. In addition, each section includes discussion of limitations and restrictions of the research and citation of databases accessed in the literature search.

The research synthesis does not include media, materials, and technology pertaining to parent education, use of interpreters, and curricular areas such as math, reading, social studies, science, music, art, health education, drug and sex education. The ages of the deaf and hard of hearing children addressed in the document range from preschool to grade 8. Therefore, media, materials and technology for deaf adult learners, postsecondary instruction,

vocational education, transitional programs, and adolescent substance abuse are not included. Although materials to develop American Sign Language are included, manually coded English and Cued Speech are not. Perhaps future synthesis can deal with these content areas.

Target Population

Incidence

According to Flexer (1991), deaf and hard-of-hearing children, including all degrees of hearing loss from mild to profound, constitute one of the largest populations requiring special services within the schools. She reports 66,000 educationally handicapped children in the United States with moderate, severe, and profound bilateral losses. The numbers increase significantly when children with mild bilateral hearing loss are included. Various prevalence rates of deaf and hard of hearing children have been cited in the literature. Freeman et. al. (1981) and Rodda & Grove (1987) report rates of chronic childhood hearing loss from .1 to .2% of the general population. Hallahan, Keller, and Ball (1986) report prevalence rates for states from .09 to .35% of all students, with a mean of .19%. Demographic data indicate that the incidence of profound congenital deafness has been estimated at approximately .1% of all births, and the number of school-age hard of hearing children has been estimated at 1.6% of the school population (Ross, et al. 1991). Ross, et. al. believe that prevalence rates are higher because these figures do not include those children with very mild or unilateral hearing losses. The variability of reported prevalence and incidence rates probably reflects differences in the definitions of "deaf", "hard of hearing", and what constitutes hearing loss. In addition, many of the prevalence figures do not include multiply disabled children for whom hearing loss is a secondary disability.

Characteristics of deaf and hard of hearing children

Definitions

Although complete agreement as to definitions of the terms "deaf" and "hard of hearing" does not exist, the definitions discussed in the following paragraphs have been accepted by the majority of the deaf community. These definitions are used in this research synthesis.

The terms are used differently in a cultural sense compared to medical or audiological use. **Culturally Deaf** people consider themselves to be members of a Deaf community which may also include hearing people who support the goals of the community. All culturally Deaf people have some degree of hearing loss, but the loss may be profound, mild to moderate, or even unilateral. Culturally Deaf individuals communicate visually through the use of sign language and share a variety of interests, experiences and backgrounds. The majority of these individuals were born with hearing loss or acquired it early in life (Schein, 1989; Baker and Cokely, 1980).

A **deaf** individual in the medical or audiological sense is one who experiences significant difficulty understanding speech through audition alone, with or without amplification. The deaf child's primary mode of communication is visual involving speechreading, sign language or both. Audition functions as a support sense (Anon, 1981; Schein, 1989; Ross, et al., 1991). The labels "deaf" and "hard of hearing" should not be applied based solely on the audiogram. A child with a profound hearing loss may function either as a deaf or hard of hearing person.

A **hard of hearing** individual is someone who has developed basic communication skills primarily through the auditory channel; audition serves as the primary communication mode, with vision used as a support sense. Most hard of hearing children have more residual hearing than deaf children and can benefit to a greater degree from amplification in the understanding of speech. The vast majority of hard of hearing children, however, can benefit from training in speechreading, communication strategies, auditory skills, speech and/or language in addition to amplification to communicate effectively through a spoken language.

There are some children who cannot be neatly categorized as deaf or hard of hearing. They may function primarily through audition in some situations (eg. discussion of a known or restricted topic), but depend primarily on vision for other communication situations. Although educational needs tend to differ depending on whether a child functions as deaf or hard-of- hearing, all children need to be evaluated as individuals in the development of educational plans.

The term "**hearing impaired**" is used by some people to mean hard of hearing. Others use the term in a generic sense to include all degrees of hearing loss. Because of the

lack of agreement about the meaning of this term and because the deaf and hard of hearing communities considers it objectionable, the term "hearing impaired" will not be used in this research synthesis.

Prelingually deaf or hard of hearing children are those who have acquired hearing loss before attaining fluency in the spoken language of the home, between two and three years of age (Schein, 1989). The hearing loss may be present at birth (congenital) or acquired sometime after birth. Those children who acquire their hearing losses after attaining basic fluency in spoken language are considered **postlingually** deaf or hard of hearing. Prelingually and postlingually deaf children may have identical audiograms, but often have distinctly different needs and function very differently. According to a national survey published by the American Annals of the Deaf (Schildroth & Hotto, 1993) 94% of 32,000 children in the United States with hearing loss acquired their losses before age three.

Degree of Hearing Loss

There has been some attempt to evaluate the effect of degree of hearing loss on communication and academic achievement. Karchmer, Milone, & Wolk (1979) reported that degree of hearing loss strongly influences type of educational placement, speech intelligibility, use of amplification, and the particular communication method the student is likely to use. They found that 86% of a group of children with hearing losses of 70 dB or less were judged to have intelligible speech as compared to 55% of another group of children with losses between 71 and 90 dB and 23% of a third group with losses above 90 dB. Jensema and Trybus (1978) conducted a survey of deaf and hard of hearing children and reported that as degree of hearing loss increases, use of sign language increases, speech intelligibility decreases, use of amplification increases except for those with the most severe losses, and residential educational placements become more common. Expressive language in most cases took the form of speech up to a 70 dB loss; above 70 dB expressive communication was primarily through speech and sign language or sign language alone.

Several studies have reported decrease in academic achievement with increase in degree of hearing loss (Davis, Shepard, Stelmachowicz, & Gorga, 1981; Quigley & Thomure, 1968). In a later study, however, Davis, Elfenbein, Schum & Bentler (1986) correlated degree of hearing loss and educational performance for children with various degrees of hearing loss

and concluded that degree of hearing loss alone cannot be used as sole predictor for academic performance. Musselman, Lindsay & Wilson (1988) examined the effects of hearing loss, age, intelligence, type of educational program, and type of communication in the home on language and academic achievement. In contrast to the findings of Davis et al (1986), they found degree of hearing loss to have the most signifcant correlation with language and educational achievement.

The literature suggests that although a clear relationship between degree of hearing loss, communication skills, and academic achievement exists, other factors seem to influence these relationships.

Age of Onset

Most children with congenital and acquired prelingual hearing losses of 70 dB or greater experience delays in acquiring receptive and expressive English language skills. Speech and English language skills of children with less severe losses depend on the degree of hearing loss and the age at which use of amplification and language training began. Speech and English language development of children with postlingual onset of hearing loss depends on degree and configuration of hearing loss, how soon after onset of loss intervention began, developmental level at time of hearing loss, and type of intervention. English language skills of children who had acquired fluency in spoken language before acquiring hearing loss generally do not deteriorate, but speech frequently becomes less intelligible because of inadequate auditory feedback (Johnson & Evans, 1991).

Deaf children of deaf parents who use American Sign Language (ASL) as their normal mode of communication tend to progress through stages of acquisition of ASL in the same manner that hearing children progress through stages of spoken language acquisition. Such children may show delays and difficulties with the development of English, but it is incorrect to assume that general language problems exist. These children frequently come to school with a well formed ASL language base which may be used to help develop English skills.

Few studies have specifically examined the effects of onset of hearing loss on educational performance. Allen and Osborn (1984) compared reading comprehension scores of students who had incurred hearing loss before age three with others who had lost hearing after age three. Separate comparisons were made for deaf children who were mainstreamed

and for deaf children in self-contained programs. Scores of the postlingually deafened children were higher than those of the prelingually deafened children within the mainstream educational settings. However, the prelingually deaf children scored higher than their postlingually deafened counterparts in the self-contained classes. Apparently, age of onset as a predictive variable was confounded by type of educational program. Further research is needed to isolate age of onset as a predictive variable .

Language of the Home

The majority of deaf children are born to hearing parents who, in the United States, use English as their native language. Even when hearing parents use sign language in the home, most signs are in English form. There are, however, a small group of deaf children who are born to deaf parents, most of whom use American Sign Language in the home.

Much of the research since the 1960's documents that deaf children of deaf parents perform better than deaf children of hearing parents in academic achievement and emotional adjustment (Moores, 1987; Quigley & Kretschmer, 1982; Schlesinger, 1986; Weisel, 1988). It is not clear, however, whether this difference is attributable to mode of communication, hearing status of the parents, degree of hearing loss, age of onset, or age at intervention.

Vernon and Koh (1971) compared the written language skills and overall academic achievement of three groups of deaf children: deaf children of deaf parents with no preschool training, deaf children of hearing parents with no preschool training, deaf children of hearing parents with preschool training. They found that the children of deaf parents scored higher than the two groups of children with hearing parents. Vernon and Koh concluded that the children's early exposure to American Sign Language resulted in high academic achievement.

Contradictory results were found by Brasil and Quigley (1977). They compared academic performance and English linguistic skills of two groups of deaf adolescents from total communication programs. The group whose parents used manually coded English (signs in English format) in the home scored higher than the group whose parents used American Sign Language. There was no discussion in the study of whether both sets of parents were equally competent as signing models.

Corson (1973) compared the reading and writing skills of four groups of deaf children: Group one had deaf parents and used sign language at home; Group two had hearing parents

and used sign language at home; Group three had deaf parents and used oral communication at home; Group four had hearing parents and used oral communication at home. The first two groups attended total communication programs; groups three and four attended oral programs. Results indicated that the children of deaf parents outperformed the children of hearing parents regardless of the mode of communication in the home or the type of educational program. Apparently the use of sign language in the home is not sufficient to explain the academic superiority of deaf children of deaf parents.

Apparently, the specific language of the home and the specific educational methodology are not the sole factors responsible for differences in educational performance of deaf children. Weisel (1988) found that deaf children with two deaf parents "showed higher levels of reading comprehension, were better emotionally adjusted, had better self images and were more motivated to communicate with both hearing and hearing-impaired people" as compared with deaf children having two hearing parents. He suggested that the educational superiority of the first group of deaf children may be attributable to the early and continuous exposure to sign language and a difference in "family climate" present in the homes with deaf parents.

Research data suggests that adjustment and attitudes of the family to the hearing loss and the quality of communication in the home are the primary factors responsible for superior educational achievement of deaf children. Easy comfortably communication with a deaf child facilitates development of a rich knowledge/experience base which is a significant factor in reading readiness. A delayed, impoverished experience base is a major problem for many prelingually, severely or profoundly deaf children from hearing families. Therefore, intervention programs are needed to help parents accept and adjust to hearing loss and maximize communication with their deaf children.

Sign Skills of Teachers

One major confounding factor in studies which evaluate linguistic and academic achievement of children in educational programs using sign language is that many teachers of the deaf do not recognize the visual needs of their students. They are not fluent signers and therefore cannot serve as communication models for their children. They often have

difficulty understanding children who are fluent signers in their own classrooms (Marmor & Pettito, 1979; Kluwin, 1981; Woodward & Allen, 1988).

Reading

Although the intelligence and general ability of deaf students are not different from the rest of the population, reading achievement has been much lower for deaf children. Based on surveys carried out since 1969 by the Center for Assessment and Demographic Studies at Gallaudet University, Quigley and Paul (1986) noted that upon completion of secondary school the average deaf student performed at the level of an average 9 or 10 year old hearing student (fourth or fifth grade reading level). They pointed out, however, that there are deaf students who have achieved reading levels comparable to their hearing peers (Quigley and Paul, 1989).

An adequate internalized English language system is necessary to understand written English. Although deaf children have the same learning potential as their hearing counterparts, the considerable delay in development of English language vocabulary and syntax interferes with learning to read (Quigley and Paul, 1989; Johnson & Evans, 1991).

Types of Educational Programs

Communication Methodologies

Oralism

Oral education, also called aural-oral, does not use sign language. Instead it relies on developing good use of residual hearing, speechreading, and speech skills through which students learn and communicate. Some programs rely more heavily on auditory skills, while others give equal weight to speechreading. Oral education works best when children have usable residual hearing and when there is an existing English language base as with postlingual deafness. The goal of oral education is complete integration into hearing society. Disadvantages of this approach are that many children are unable to learn a first language from the limited auditory cues available and that it discourages participation in the deaf community. Since English language acquisition is delayed and sign language is withheld, academic achievement is often seriously affected. When oral education works well, it maximizes the ability of the deaf individual to communicate with hearing people.

Total Communication

Most of the deaf education programs today subscribe to the philosophy of Total Communication. Total Communication requires the use of appropriate aural, manual, and oral modes of communication to maximize communication in all situations with both hearing and deaf people. Although it does not require simultaneous speech and signing in all or most situations, speech and some form of sign language is usually used simultaneously. Total communication practitioners generally use some form of signed English in which American Sign Language (ASL) vocabulary is presented in English grammatical format. "Signing in English" may be done in a number of ways. Although ASL vocabulary is usually presented according to the grammatical structure of English, some educational programs require that every English word be signed, while others omit function words such as "a", and "the". It is not clear how different modes of "signing English" affect educational outcomes.

Proponents of Total Communication believe that if children consistently see English represented on the hands as well as seen on the lips and heard thorough amplified residual hearing, learning of English language will be facilitated. English presented by the hands can reinforce English presented orally.

Opponents argue that English is not consistently represented on the hands; it is often absent or misrepresented, providing confusing and conflicting signals to deaf children. Additionally, conversational pacing and phrasing of English is distorted. Use of selected grammatical features of ASL can enhance English signing but many hearing users do not have this knowledge and cannot adequately use the ASL systems. Advocates of ASL alone argue that signed English systems mix features of two languages, effectively representing neither.

Total Communication provides flexibility, permitting the instructor to vary the type of language input from situation to situation. The system works best when Total Communication is used consistently in the home as well as in the classroom.

Bilingual/bicultural (ASL) programs

This educational approach is based on the premise that American Sign Language with its unique grammatical structure is the naturally acquired language of deaf people. Therefore, deaf children can best learn English as a second language in written form using ASL as the

language base and as a teaching vehicle. This type of prog.am is being implemented in a number of residential schools (eg. Indiana School for the Deaf). It requires the sole use of ASL in all classes until children demonstrate ASL fluency; at that time English is taught in written form. Fingerspelling may be used from the beginning and printed materials may be used as appropriate, although it is unclear how printed materials are used with young children who do not know English. Hearing parents are encouraged to use ASL in the home to supplement classroom communication. Since most deaf children are not exposed to ASL in the home, it often requires a number of years to achieve ASL fluency. Although bilingual/ bicultural programs advocate amplification, auditory training, and speech training, it is unclear how listening and speech skills are to be developed in children who are not continually exposed to spoken language.

Cued Speech

Cued Speech is designed to visually represent the sounds of English (or any other spoken language) rather than words or concepts. It consists of eight finger configurations denoting consonants and four hand positions around the face denoting vowels. In running speech the hand cues are coarticualated with spoken syllables. The hand cues are designed to allow the speechreader to perceive differences between homophenous sounds that would otherwise look identical on the lips. Therefore, the hand cues in conjunction with the information on the lips allow a child to clearly see every sound of spoken English. Children are expected to match the visual cue with the visible mouth movement and then be able to acquire the structure of spoken English through natural acquisition processes.

In contrast to sign language, Cued Speech is not a language, but a system to facilitate reception of the spoken word. It can be learned very quickly and used to facilitate English language development in the home and school. It does not confuse the two languages, English and ASL, in any way. Cued Speech is being used in selected mainstream programs around the country (eg. Montgomery County, Maryland public schools, Fairfax County, Virginia public schools), but has received little attention from researchers and has not received the support of most deaf people and educators. There is a need for research on the effectiveness of this system as a way of developing reception of spoken English

Educational Placement Alternatives

Self-contained classes

Self-contained classes for deaf students, either in day or residential schools, represent traditional educational settings.

Some of these programs are oral while others use some form of English signing or ASL. They offer highly structured programs. Students attending self-contained classes tend to have more severe losses than those attending integrated classes (Karchmer and Trybus, 1977). The children in programs using sign language tend to come from deaf or hearing families that stress deaf culture. Residential and self-contained day schools tend to have a greater availability and variety of audiologic and other support services (Kretschmer and Quigley, 1982). They also provide a larger core group of deaf peers for interaction and will sometimes have deaf teachers as well. Deaf teachers tend to sign more fluently than hearing teachers, thereby serving as good communication models.

Partial Mainstreaming

Partial mainstreaming occurs when a deaf child attends some classes with hearing students and others in a self-contained environment, usually a resource room or one-to-one instruction. In some public school environments, self-contained classes for deaf students are used instead of the resource room. This placement is appropriate for those deaf children who cannot handle all of the academic material in regular education classes, but function on grade level for some subjects.

Social Mainstreaming

All academic subjects are taken in a resource room or classroom for deaf children. The deaf children, however, are placed in regular-education classes for such activities as music, art and physical education; they are also given the opportunity to interact with hearing children during lunch and recess.

Full Mainstreaming

When the deaf child is fully mainstreamed, he or she attends a local public school in which all subjects are taken in regular education classes with regular education teachers. Typically the child uses an FM classroom amplification system instead of the personal

hearing aid and receives educationally related language management. Some children who rely on sign language may be mainstreamed with the help of a full-time interpreter.

Deaf children in any educational setting rely on vision to access educational material to a far greater degree than hearing children. Mainstream classrooms may not be designed to provide total visual access and teachers may not be trained to structure their teaching styles to provide sufficient visual input. Sign language interpreting, if not used judiciously, may compete with visual stimuli in the classroom. These factors should be considered when mainstreaming is contemplated.

Regardless of the type of mainstream program in which a child is placed, support services are needed. Services include classroom amplification, speech, language, and auditory training, academic tutoring, amplification monitoring, and interpreting.

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ASSISTIVE TECHNOLOGY FOR EDUCATION

Beth Singer, M.S.

A. Literature Search

This research synthesis contains references found from the CATS and ERIC databases. CATS lists resources owned by members of the Washington Research Library Consortium (WRLC). ERIC is the on-line version of the databases produced by the Educational Resources Information Center. ERIC includes two subfiles: Resources in Education (ED), from 1966 to the present; and the Current Index to Journals in Education (EJ), from 1969 to the present. Only articles and books published since 1980 are included in this research synthesis. The literature review for what makes quality media, materials, and technology (MMT) for deaf and hard of hearing children yielded meager results. Although many educators of deaf students are using MMT, little of their work has been documented.

B. Visual Technology

1. Microcomputers

Deninger (1985) reports that 96% of state schools for deaf children use computers as part of their instructional programs. Seventy six percent of all deaf education programs (including mainstreamed settings and special classrooms) report some instructional use of computers. Use of computers in school programs has likely increased since the time of Deninger's study.

Much of the literature focuses on computer-assisted instruction (CAI) in the classroom. In fact, Braden and Shaw (1987) identify 162 references that focus primarily on the application of computers for educational purposes. They report that slightly more than 9% of those references evaluate CAI efficacy, with the majority of the research descriptive in nature. Braden and Shaw question whether CAI has a true positive impact on educational achievement in deaf children compared to alternative forms of instruction. What they term "poisonous" side effects - decreased interaction among children or between children and teachers - has not been addressed in the literature.

Despite Braden and Shaw's report, computers are here to stay. Even without hard documentation, the computer appears to be a perfect tool to use in deaf education, largely because it is a visual medium. Even if computers and other instructional materials are equal in effectiveness, there is merit in having students learn to use computers as preparation for entering the work world.

Apple computers are most prevalent in educational settings, with use of IBM and compatible computers increasing (Kurlychek, personal communication). Consequently, most educational software is written for Apple computers, although software for the IBM is also available.

The ability to hear plays a small part in being able to use a computer effectively. The audible beep that signals a user to an error is an example of an instance in which audition might be required. A software program that visually displays the audible beep is available. It is called SeeBEEP. This program allows the user to run standard text or graphics applications and not miss any error messages. Each time the computer sounds an audible beep, the user can choose to have a visual, on-line screen message appear at the cursor location, or flash the entire screen. Additionally, the flashing beep can be as short as .2 seconds or as long as two seconds. This program works with most IBM or compatible computers and requires DOS 3.0 or higher. It is available from Microsystems Software, Inc. of Framingham, Massachusetts.

Apple computers address this situation in a different way. In the newer computers, (Macintosh and Apple II GS), the system software is designed to provide a visual cue when the volume control is set to zero. With the older Apple IIs, a visual indication could only be obtained if it were written into the computer software program being used. Another possible way of being alerted to a computer beeping sound with Apple II computers is to couple the sound system of the computer to a flashing light set-up (Moulton, 1993).

The criteria that make educational software effective for a deaf or hard of hearing child are the same as those for a successful program for a hearing child. Very few software programs are designed specifically for deaf and hard of hearing children; those that are, are not necessarily better or more effective.

Ken Kurlychek, materials evaluator at the Model Secondary School for the Deaf (MSSD), developed and maintains the Software Evaluation Clearinghouse for Educators of the Hearing Impaired (SECEHI). The clearinghouse is an educational software lending- library with a collection of more than 600 commercially available software programs for Apple and IBM computers. The collection is listed in a catalog titled, Software to Go. Schools interested in borrowing software pay a nominal annual membership fee. There are currently 110 member schools with 45 schools actively borrowing. Schools may borrow the software for up to four weeks. Teachers are asked to complete a review form and return it with the software (Abrams and Kurlychek, 1989). From those evaluation forms, Kurlychek has compiled a list of features that make a software program successful (Kurlychek, personal communication).

The most frequent response from teachers was that a particular program was enjoyable to students. These programs tended to use a game-like format with high-resolution graphic displays. Programs designed in this fashion motivated the students to use the software and thereby learn the material. Reinforcement for correct answers was provided by a graphic rather than a word. For example, a clown jumping and clapping indicates a correct response as opposed to merely displaying the word "correct" or "good." Similarly, positive feedback should be used to correct mistakes. Large displays of the word "wrong" should be avoided; some kind of icon encouraging the student to "try again" is preferable.

Text should be kept to a minimum, especially for younger children. The challenge is to make the instructions readable without being overly simple. Any auditory components of the program must be modified to include a visual component be it a graphic or sign language display.

Teachers preferred programs that displayed instructions on the screen and lessened the need for the manual. These programs require minimal adult involvement and allow students to work more independently. Menu-driven programs are one such example.

Teachers and students preferred programs that use visual cues to provide information as to what the computer is doing when screens change. Depending on the computer's speed, a student may not know that the computer is loading a program, processing a response, or displaying a new screen. It is important to inform the student of this. Effective programs

will display a message such as "loading", or "please wait a minute." These prompts also help prevent the student from indiscriminately pressing keys to get a response. In addition, a successful program will have foolproof keying, i.e., hitting the wrong keys will not cause the program to re-boot or exit the student's document.

Teachers also liked programs that were flexible. This means the program could be used in a variety of subject areas with a variety of students. Teachers liked the ability to adjust the level of difficulty to match their students' abilities. They also reported wanting the ability to modify the program by adding specific vocabulary words.

2. Captioning Systems

Captioning is the process by which the audio track on television shows and videotapes is transformed into text form. Captioning can be closed or open. With closed-captioning, the text is encoded onto Line 21 of the vertical blanking interval. All captioned television shows and videotape movies are closed-captioned. A decoder is needed to retrieve the captions and make them visible on the television screen. Until recently, the decoder was a separate piece of equipment that connected to a television. Today, all televisions at least 13 inches in size that are manufactured for use in the United States contain a decoder chip, making the decoder box unnecessary.

Captioning can be a very expensive process, costing from $500 to $1,000 per program hour. This is well beyond the budget of most schools interested in having their educational and training films captioned. Open-captioning is an option for these schools. A decoder is not necessary to view open-captioned videotapes. The videotape can be played in any videocassette recorder (VCR). This also allows the original videotape to be captioned in various ways. Open captioned educational and entertainment films and videotapes are available on a free loan basis to school personal. The U.S. Department of Education funds this program. Currently the captioned films and videos are distributed by Modern Talking Picture Service of St. Petersburg, Florida.

Any pre-recorded videotape can be captioned. The equipment needed to produce open-captions is a computer system and captioning software, two VCRs (one to play the

original videotape and the other to record the open-captioned tape), a television monitor, and a decoder.

There are many benefits of in-house captioning. It permits greater latitude in choosing videotapes and adapting them for educational use. Teachers can create captions appropriate to their students' language levels and reading speed. Schools can assemble libraries of captioned videotapes for everyone to share (Singer, 1991).

Currently there are four companies that produce open-caption software for both IBM computers (or compatibles) and Apple computers. The companies that produce IBM compatible software are Image Logic (AutoCap), The Caption Center (CC Writer) and Computer Prompting and Captioning Company (CPC-700). Silent Software produces FastCap software for the Apple. These software programs are menu-driven and easy to use, even for a novice computer user. The Caption Center has also produced open-caption software designed specifically for children. The software is called CC Schools. Research is being conducted to evaluate its effectiveness. Teachers at the Marie Katzenbach School for the Deaf in Trenton, New Jersey, were shown a demonstration copy of the software and commented on how easy it was to learn and use. Harkins, 1993)

3. Computer-Assisted Notetaking

Computer-assisted notetaking (CAN) is a technique that uses computer products to enhance communication access for hard of hearing people. This technique uses a computer and display to provide live notes of a meeting, lecture, or group discussion. The notes can be displayed on a computer screen, a television monitor, or projection screen. A transmissive overhead projector and projection pad are needed to display the notes on a screen to a group of people. The notetaker types a summary of what is being said. CAN should not be confused with real-time captioning, as it is not intended to provide a verbatim transcript, but rather summary notes. Of course, depending on the skill of the notetaker, and the speed at which a speaker is talking, near verbatim notes are possible (Virvan, 1991).

A computer equipped with a word processing program or text editor is needed to provide CAN. One advantage of this technique is that it can be made portable by using a laptop computer. It is helpful if the word processing program can support an expansion

software program in the background, such as Productivity Plus (PRD+). An expansion software program is a time-saving device that allows the notetaker to use abbreviations (i.e. "hoh" for hard of hearing). When the abbreviation is followed by pressing the 'Enter' key, the full word appears on the screen. People's names and other frequently used vocabulary can be pre-programmed into the computer. So that projected notes can be read easily by a large group, the brightest transmissive overhead should be used. While the projection pad can be monochrome, it should be bright, have high resolution, and even contrast.

CAN has become very popular among hard of hearing groups. Of 103 people surveyed by the Technology Assessment Program at Gallaudet University, more than 80% reported watching the notes. Everyone who watched the notes said the notes were "very helpful" or "somewhat helpful." Only 20 people reported not watching the notes at all because they could either not see the screen from their seats, could hear the speaker well enough, or found the notes distracting when trying to speechread the speaker (Virvan, 1991).

CAN may or may not be feasible in a K-8 classroom situation. Again, no research is available that documents the technique's use with hard of hearing children. Educators should consider students' reading levels as well as the fact that CAN does not provide a verbatim transcript of what is said. Another consideration is the availability of a full-time notetaker who is skilled in processing spoken language into a written format. There are advantages to using CAN in the classroom. If the notes are saved and printed out, a student can get a hard copy of the day's lessons, allowing the student to concentrate more on what is being said instead of trying to take notes and listen to the teacher at the same time. Several colleges and universities have expressed an interest in exploring CAN for their students. A university setting might be more conducive for this type of support service (Virvan, 1993).

The Technology Assessment Program (TAP) at Gallaudet University and the Rehabilitation Engineering Center (REC) at the Lexington Center in Jackson Heights, New York, are collaborating on a project to test the feasibility of remote CAN for meeting and lecture situations. For remote notetaking, a notetaker would provide notes without having to travel to the location of the meeting or lecture. The notetaker would hear what the speaker is saying through a telephone link-up. The notetaker's computer would be connected to a

modem so that the notes could be transmitted for display. This would address the issue of finding a skilled notetaker in a given locale.

Unlike CAN, real-time graphic display (RTGD) is a computer-based system that converts phonetic shorthand into print in real-time. Stinson et al. (1988) surveyed hard of hearing and deaf college students enrolled in classes using RTGD along with sign language interpreting and paid student notetakers. During lectures, a stenotypist inputs the phonetic shorthand equivalent of what is being said. The system converts the code to print which can be displayed on a television monitor, a projection screen or be printed as hard copy.

Students reported higher ratings of understanding with real-time text as compared to interpreting. The students from a mainstream educational background were more likely to prefer the RTGD compared to students from residential school settings. Their conclusion was that students who are highly skilled in reading, writing and speechreading were more likely to prefer the RTGD over an interpreter. Stinson et al. emphasize that these students are proficient skilled readers. These findings further support the idea that CAN and RTGD are support services requiring higher reading skill levels than those normally found in the K-8 population.

However two of the products used for CAN, the transmissive overhead projector and projection pad, can take on other applications in deaf education. Any computer screen can be displayed onto a projection screen with this equipment. This might be useful for teachers who want to display charts, computer menus, and any combination of text and/or graphics being used for instruction purposes.

4. Interactive Videodisc

The advent of interactive videodisc systems in education has allowed students to become active learners instead of passive learners. Interactive videodiscs are very flexible, providing for random access, endless repetition, and the ability to freeze a single frame while maintaining high clarity. Entire movies, filmstrips, pictures, and books can be stored on one disc. Information can be presented at the user's own pace and level. These characteristics make interactive videodisc ideal for deaf and hard of hearing students who often have difficulty mastering the interactions between language and action. Through the use of this

technology, language concepts can be represented visually (Propp, Nugent, Stone, & Nugent , 1981; Jones, 1986; Helsel, 1988).

The equipment necessary for interactive video are a computer processing unit and display monitor, a videodisc player, and an interface card to connect the video machine with the computer. A printer is optional.

The Media Development Project for the Hearing Impaired (MDPHI) at the University of Nebraska was one of the first groups to develop, produce, and evaluate videodisc programs for deaf students. MDPHI's series of discs was designed to teach language development, social studies, and fingerspelling. One of its first discs, "Israeli Boy: Life on a Kibbutz," used multimedia to include teacher guide materials, vocabulary instruction, filmstrip-type sequences and interactive quiz sections. This disc was evaluated with students and teachers at the Iowa School for the Deaf and the Nebraska School for the Deaf. Students reportedly had no difficulty using the technology, and it was concluded that videodisc was an effective tool for education (Propp et al., 1981).

Another program, developed at the Pennsylvania State University by Prinz and Nelson was designed to teach literacy skills to deaf preschool children. Known as ALPHA, the program was originally designed as a CAI program using computer-generated animation to teach English grammar skills. The videodisc version, developed in 1987, uses videodisc motion sequences instead of computer generated animation to add a greater degree of realism. For example, ALPHA can show the difference between "cat chases ball" and "cat chases rabbit." Prior to interactive videodiscs, a teacher's only option would be to use a still picture to demonstrate this noun-verb sequence. With ALPHA, the noun-verb interactions come to life, eliminating the need for abstraction (Helsel, 1988).

One major benefit of interactive video in deaf education is that it allows for bilingual language instruction for deaf children. American Sign Language (ASL) video can appear with an accompanying English language text. This is the format used with /HandsOn/, one of the newest videodisc programs to combine sign language and English. /HandsOn/ is a joint research venture with IBM's Thomas J. Watson Research Center in New York and the University of California at San Diego. Currently being used at the California School for the

Deaf at Fremont, it allows students to go back and forth between an ASL video and English print version of a story. Its design is based on the premise that students work best when presented with options and when allowed to make their own decisions. Students can choose to read a story, watch a story, caption a story or review vocabulary. Results of some initial evaluations of the /HandsOn/ program show students answering reading comprehension questions significantly better after using the program (Hanson & Padden, 1989; Copra, 1990).

Another disc developed by MDPHI was encoded with closed captions. This disc demonstrated the possibility of videodiscs having closed captions. Jones (1986) notes an advantage of captioned interactive videodiscs over captioned videotapes in relation to reading speed and comprehension. It is an accepted fact that one cannot read as fast as one can listen. Despite the push for verbatim captioning, captions are often edited to allow for a comfortable reading level. In an educational setting, this can result in oversimplification, with the student receiving minimal linguistic benefits. When interactive videodisc programs are used, a single frame can be frozen to allow the student to read an entire verbatim caption. The linguistic content is maintained and the student can proceed at his/her own rate.

King (1993) reports that the availability of captioned multimedia programs remains a problem for deaf and hard of hearing people. More entertainment than educational programs are captioned on videodisc. Even when videodisc programs are closed captioned, problems exist when they are used in an interactive environment. Captions embedded in analog video can be garbled or disappear temporarily or permanently when viewed randomly. Sometimes the captions appear over scene changes or are out of sync with the program's audio.

King further states that despite these problems, the future of video is digital, rather than analog. Digital audio is both relatively easy and inexpensive to create. This poses a major obstacle for computer users who depend on visual access and cannot take advantage of digital audio's widespread use. King makes a case for multimedia developers to include captioning in their products. According to the Americans with Disabilities Act (ADA) of 1990, reasonable accommodations need to be made for disabled people. Second, she states that captioning can be helpful to more than deaf and hard of hearing people. Many speakers of English as a second language can read captions to try to improve their English language skills. Captioning is also being used in museum exhibits, and the new decoder chip

televisions can be used in bars and other noisy environments to provide access to the spoken word when conditions make it difficult to hear.

King (1993) lists three conditions that are necessary before captions can routinely be included in multimedia programs: "provision of captioning capacity within the multimedia environment, tools for creating multimedia captions, and extensive use of captioning capacities." (p. 8)

C. Auditory Technology

Assistive listening devices and systems (ALD) are used to increase the signal-to-noise ratio in difficult listening situations. Close placement of the microphone to the sound source helps to negate the adverse effects of reverberation, background noise, and distance. The original signal is delivered to the listener's ear. Ross et al. (1982) measured noise levels in 45 classrooms under normal conditions (i.e. children present). They found the average noise level to be 60 dB (A) with a standard deviation of 7 dB. This supports the fact that classrooms can have poor acoustics for optimum listening. When a person with a hearing loss is in this environment, the situation is even worse. Any amplification system that is selected for use with a deaf or hard of hearing child should provide as much as possible of the important acoustic speech features in the highest quality signal.

1. Induction Loop Systems

Induction loop systems consist of an audio power amplifier that is connected to a cable, or loop. The loop is placed around the perimeter of a room, or a section of a room. The amplifier receives the signal via a microphone, tape recorder, or other source. The signal is converted into an electrical signal, amplified, and then sent through the loop. The signal is transmitted in the form of electromagnetic energy that can be received by the telecoil in a hearing aid or by a personal induction receiver. The listener must be seated within the looped area to receive the amplified sound.

Large area induction loop systems can be permanently installed in theaters or churches, or be portable for use in meeting rooms or lecture halls. Small area induction loop

systems are also available for use at work to loop a meeting table, or at home to loop an area to watch television.

Some benefits of induction systems are that they are relatively inexpensive, and it is easy to use and troubleshoot. They require a minimum amount of equipment because the listener uses his/her own hearing aid set to the telecoil position. One drawback of an induction loop system is that weak spots in the loop cause the transmitted signal to be inconsistent in strength. Another disadvantage is that the electromagnetic signal travels through walls causing interference in adjacent areas with a loop. This is referred to as spillover. One other weakness of the system is that it does rely on an individual's hearing aid telecoil. Many smaller hearing aids do not have telecoils, and for those that do, it is usually the 'weak link' of the aid. If a person's telecoil is malfunctioning or weak, the loop will not be effective.

Induction loop systems are being used in K-8 classrooms. There is no documentation to support their effectiveness in this situation; all reports are anecdotal. Induction loops are often used in communal areas such as auditoriums and large lecture halls where spillover is not a consideration.

One company, Oval Window Audio of Nederland, Colorado, has addressed the spillover and weak signal problems by developing a 3-D loop system. The cables of the 3-D loop system are embedded in a special mat that is placed under carpeting. Because the three loops are oriented at different angles, the 3-D loop system provides better field uniformity, resulting in a constant and clearer signal. Spillover is minimal allowing adjacent rooms to be equipped with the 3-D loop system (Hendricks & Lederman, 1991).

Another innovative product by Oval Window Audio is the Multisensory Sound Lab. It is an audio system that amplifies sound while simultaneously providing visual and vibrotactile displays. Sound signals from microphones, musical instruments, tape recorders, compact disc players, and other sources are processed and directed to loudspeakers and a specially designed vibrating floor. The floor vibrates slowly or quickly, depending on the sound frequency. Intensity and rhythm are also perceived through the floor. There are two ways to visually display the signal. One is via a spectrum analyzer that displays the harmonic content on a color television as vertical bars, changing in location and height

depending on the sound characteristics. The other is via a seven-foot column consisting of three banks of colored lights that respond to different sound frequencies and intensities.

The Multisensory Sound Lab was created to teach the science of sound to deaf students. Other applications, for hearing students as well as deaf and hard of hearing students, include speech therapy, music instruction and science education.

2. FM Systems

Frequency modulation (FM) systems are the most versatile of all the listening devices. FM systems work on the same concept as FM radio waves. The Federal Communications Commission (FCC) has reserved the frequency band from 72 to 76 MHz for FM use. This allows for 40 narrow-band channels and 10 wide-band channels. With FM, the primary signal is picked up by a microphone, optimally placed six inches from the intended sound source. The signal is then converted into an electrical signal which is modulated and transmitted on a radio wave to an FM receiver. The receiver demodulates the signal into an acoustic signal that the person can hear. FM can be used in conjunction with a personal hearing aid via direct audio input (DAI), a personal neckloop or with headphones.

FM systems have many advantages. They provide high fidelity gain with low harmonic distortion and a high signal-to-noise ratio. There is great flexibility in their electroacoustic fitting. The sound pressure level of the teacher's voice can be controlled. FM systems are portable, which allows for greater student and teacher mobility, and can be used indoors as well as outdoors. Spillover is not a factor with FM systems as it is with induction loops (Pimental, 1981, Berg, 1986).

Many studies have focused on the frequency response of hearing aids when coupled to FM systems (Van Tassel, et al. 1980, Berg, et al. 1983). Hawkins (1984) compared several different hearing aid/FM system combinations with nine school-aged children with mild to moderate hearing losses. He reports an improvement of +12 to +18 dB in the signal-to-noise ratio using an FM system instead of a hearing aid alone. Even with preferential seating, he noted an FM advantage. The preferred classroom hearing aid arrangement was binaural amplification with a directional microphone.

Ross et al. (1982) strongly support the use of FM auditory trainers with all hard of hearing children in order to maximize their speech perception. They cite an earlier study by Ross, Giolas & Carver (1973) where word discrimination scores were obtained on 11 hard of hearing students in two test conditions. The first condition was with their regular monaural or binaural hearing aids. The second was with an FM auditory trainer. Word discrimination scores improved 12%-76% in the second condition. These results present a strong case for the use of FM in the classroom.

Maxon et al. (1991) conducted two surveys to see how FM systems were chosen, used and accepted. Sample 1 was polled during the 1981-82 school year and Sample 2 was polled during the 1988-89 school year. Their questionnaire had three parts, addressing school personnel data, attitude data and child descriptive data. Some key findings of their surveys showed that children and their parents were not included in the decision making process regarding which FM to evaluate and purchase. Once an FM system was deemed necessary, it was often selected by the school administrator based on the lowest bid submitted.

The audiologist was the person responsible for adjusting the electroacoustic characteristics for the FM system, but not responsible for selecting and maintaining the system. This role of the audiologist did increase in Sample 2.

Both samples reported that FM systems were more likely to be accepted by elementary school children than junior or senior high school students. One way to remedy this situation is to set up support groups, as advocated by Leavitt (1991). These groups can be valuable for demonstrating and promoting the use of the assistive technology.

Maxon's survey also showed that full-time FM use declined in Sample 2 as compared to Sample 1. Along with this, daily troubleshooting only occurred 50% of the time. This is a disturbing finding as breakdown can be a major reason for not accepting or using the FM on a full-time basis.

It is obvious that fitting a child with an FM system does not ensure success. In an educational setting, much of the student's success with the device will be based on the teacher's ability to use the device appropriately and correctly. The educational audiologist also needs to be well versed in the technology being used. Annual in-services were reported

to be insufficient by Maxon's samples. They requested more frequent training for monitoring malfunctions.

3. Soundfield Amplification Systems

Soundfield amplification refers to the use of a public address (PA) type system to amplify an instructor's voice in a classroom situation. Using this system, the signal-to-noise ratio at the listener's ear can be enhanced by +12 dB, provided the ambient noise level in the classroom does not exceed 60-65
dB A (Berg, 1986). This type of auditory technology can be used with hearing, hard of hearing, and learning disabled children.

Sarff (1981) describes the Mainstream Amplification Resource Room Study (MARRS) conducted on fourth, fifth, and sixth grade students with minimal hearing loss in southern Illinois. One objective of the study was to determine if the students' educational deficits, as measured by standardized achievement tests, could be corrected in a mainstream school program. One of the intervention strategies used to achieve this objective was a soundfield amplification system. The soundfield amplification system consisted of a unidirectional microphone and a wireless transmitter worn by the teacher. A wireless transmitter receiver, a power amplifier, and two 12-inch loudspeakers were installed in the classroom. This treatment was compared to using the school's standard curriculum in a resource room setting. While pre- and post-treatment scores showed both treatments to be effective, the soundfield situation was more effective.
The increase in scores was more pronounced with the fourth to fifth grade groups than the fifth to sixth grade groups. Sarff suggests that the use of soundfield amplification may be most effective in younger children.

Some other advantages to using soundfield amplification in the classroom are that all children can benefit from the increased signal-to-noise ratio, not only hard of hearing children. Likewise, hard of hearing children are not singled out from their hearing peers. Teachers also reported liking the system because they did not have to strain their voices to be heard. They said amplification lessened their fatigue and allowed them to move around the classroom more easily.

Jones (1985) also examined the effects of soundfield amplification in kindergarten classrooms. In this study, groups of hard of hearing and hearing students were seated in the middle of a classroom. They were asked to mark multiple-choice pictures in response to the words they heard from a tape recorder. The tape recorded words were presented in three different ways: Treatment A (from a desk in a corner of the room with no amplification provided), Treatment B (from a desk close to the center of the room with no amplification provided), and Treatment C (from a desk in a corner of the room with the sound being delivered to two ceiling speakers through soundfield transmission). The lowest mean listening percentage was obtained from the hard of hearing students in the Treatment A condition. This suggests that listening problems can exist in kindergarten classes when teachers are speaking at a distance from hard of hearing students. These listening difficulties may be diminished by having the teacher move closer to the students when speaking, or by using a soundfield amplification system. Even with preferential seating, however, only 83% of the original signal is received (Leavitt & Flexer, 1991).

Although soundfield amplification has proven to be successful in specific situations, it would not routinely be the educational amplification system of choice. Leavitt (1991) cautions against using soundfield systems to guarantee reception of a high fidelity signal. Leavitt strongly advocates for a distance of six inches between the teacher's mouth and the child's ear. The only way to achieve this is by using an FM system.

D. Recommendations

Listed below are some general considerations when developing quality MMT for deaf and hard of hearing students:

Visual - Be as visual as possible. Present information in picture or graphic form whenever feasible. Text should be presented in simple language and kept at a minimum.

Accessible - Develop MMT that is initially accessible to deaf and hard of hearing students, instead of adapting the technology to fit their needs afterwards. This helps raise awareness and keep costs down.

Affordable - Develop MMT that schools can afford. School budgets are getting tighter, not bigger.

Listed below are some specific recommendations for developing quality MMT for deaf and hard of hearing students:

Microcomputers

- More integration of IBM computers in education
- Include built-in visual indicators
- Continued development of educational software programs containing the following features:
- Game-like formats with high resolution graphics
- Graphics for reinforcing correct answers
- Graphics for positively encouraging correction of mistakes
- Minimum of text and text in simple language
- Menu-driven programs
- Visual cues as to what the computer is doing
- Ability to be modified for use with different skill levels

Captioning Systems

- Develop more user-friendly, open-caption software programs for IBM and Apple computers
- Develop more open-caption software programs designed for use by students

Computer-Assisted Notetaking

- Increase use and applications of existing technology
- For large group applications where notes are being projected onto a screen, develop more word processing programs that have large font sizes and the ability to change sizes and fonts
- Develop user-friendly keyboard expansion software programs
- Develop quieter keyboards and overhead projectors

- Develop overhead projectors that work well when the lights are on

Interactive Videodisc

- Develop more captioned educational videodisc programs
- Continue to develop ASL/English videodisc programs for bilingual education
- Provide digital equipment at affordable prices
- Provide captioning capability within multimedia environment (King, 1993)
- Provide tools for creating multimedia captions (King, 1993)
- Investigate feasibility of developing materials using CD-ROM and related technology (Loeding & Abraham, 1993, Lipton & Goldstein, 1993)

Induction Loop Systems

- Develop standards for induction loop systems and hearing aid telecoils
- Continue to develop innovative products like Oval Window Audio 3-D induction loop system

FM Systems

- Promote development and use of universal cord and boot systems for direct audio input coupling of personal hearing aids to FM system
- Build systems to be more durable, reliable and easy to use and operate

Ross, et al. (1982) and Leavitt (1991) suggest that FM systems contain the following:

- Individual controls for adjusting frequency response and output of system.
- Provide auxiliary microphone input capabilities for movie projectors, multiple microphones, and other sources
- Allow for binaural reception of environmental sounds
- Easy to see and read low battery indicators
- Switch allowing for environmental microphone only, and teacher's microphone only
- Directional microphone for teacher

- For multiple speaker situation, voice-activated microphone mixing system
- Ability to switch between carrier frequency on receiver and transmitter
- Automatic recharging and shut-off when in storage/charging unit.
- Ability to operate on 9-volt battery as well as rechargeable battery

Soundfield Systems

- Install soundfield systems in classrooms to be used as a supplemental listening system

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RECEPTIVE SKILL DEVELOPMENT

Harriet Kaplan, Ph.D.

This section of the research synthesis is concerned with the development of auditory skills, speechreading, and related communication strategies. Material is included on orientation to and use of technology essential to optimal use of these skills (hearing aids, assistive listening devices, and cochlear implants).

The following databases, covering the period from January, 1981 to June, 1993) were used for this synthesis:

1. ERIC
2. Dissertation Abstracts
3. Volta Review
4. American Annals of the Deaf
5. Journal of the Academy of Rehabilitative Audiology
6. Gallaudet Deafness Collection
7. Perspectives in Education and Deafness

In addition, selected curricula and books were manually reviewed.

This synthesis deals with deaf and hard-of-hearing children from preschool through grade 8. Not included are children with central auditory processing disorders, auditory learning disabilities, deaf-blindness or other disabilities in addition to deafness.

Although review of the literature revealed essentially no research data on guidelines and criteria for media, materials and technology, there was a considerable amount of expert opinion. Therefore, the following discussion is based largely on expert opinion, including the author's own experience.

Development of Auditory Skills

Development in hearing children

Auditory skills development in hearing children is based on three sequential and overlapping levels of perception (Aslin and Smith, 1988). The most basic is the sensory primitive level in which the child becomes aware or detects the acoustic signal. The second level involves development of perceptual representations; the child uses sensory patterns to discriminate differences between sound features. The highest level is the cognitive/linguistic in which the perceptual representations are organized into meaningful units. This level involves the skills of word recognition and sentence comprehension.

Each of these levels contains sub-categories (Laughton & Hasenstab (1993). The sensory primitive level includes not only awareness but also localization of the source of the sound, selective attention to the wanted sound, and sustained attention which allows the child to focus on relevant information for increasing periods of time.

The discrimination level consists of:

1) basic determination of whether sound is meaningful or non-meaningful, speech or non-speech, linguistic or environmental
2) suprasegmental feature discrimination (stress, pitch, intonation, pauses denoting word boundaries)
3) segmental or phonemic discrimination

The cognitive/linguistic level consists of:

1) auditory memory which organizes sounds into words and words into phrases and sentences
2) auditory sequencing which orders sound patterns into sentences according to linguistic rules
3) auditory recognition and comprehension which allows ordered speech to take on meaning.

Environmental sounds take on meaning by becoming associated with internalized actual events (eg. fire siren signifies a fire).

According to Laughton and Hasenstab (1993, p. 146),

> "Auditory learning requires the integrity and interface of sound detection, auditory processing, and cognition. A breakdown at any of these levels will interfere with or inhibit auditory learning. Hearing loss negatively affects auditory skill development at all levels because learning for deaf or hard of hearing children is organized with partial or absent sound information. Without intervention, deaf and severely hard of hearing children may not be aware that objects, actions and events have auditory characteristics and that events may be symbolized by spoken language. With early and intensive intervention, most deaf and hard of hearing children can develop higher order representation and cognitive/linguistic functions but skills are often delayed. Frequently speechreading and/or sign language provide part of the necessary language input."

Intervention Principles

In order to succeed in a regular classroom, a child who is deaf or hard of hearing must be able to attend to a speaker and try to understand what is said. By fourth grade children are expected to function independently in the use of receptive language (listening and reading) and expressive language (speaking and writing) to support learning in the content areas. Therefore, the child must master the hierarchy of listening tasks described in the previous section on normal development of auditory skills.

Training in auditory skills is an essential component of all types of programs. It is needed by children with all degrees of hearing loss and for optimal use of hearing aids, assistive listening systems, and cochlear implants. Auditory skill development is maximized when combined with speech production activities and oral language acquisition (Paterson, 1982; Ling, 1978; Ling & Ling, 1978). Therefore, speech stimuli using linguistic forms and structures appropriate for the child's level of language development should be used for training rather than non-linguistic sounds. However, it is appropriate to include some work on identification of meaningful environmental sound.

Early auditory training programs focused on discrimination between nonverbal sounds such as bells, drums, and whistles and later progressed to speech sounds and words. They tended to exclude the more complex types of verbal communication that children need in life situations. Ling (1986) stressed that discrimination training should not be a primary focus. Instead, real life experiences should form the basis of listening training. Discrimination activities should be used only for remediation when children are unable to succeed at identification and comprehension activities.

All auditory training curricula should include activities in the areas of detection, localization, selective attention, discrimination, auditory memory and sequencing, closed set identification (limited response choices), open set identification (unlimited response choices), and comprehension. In addition, figure-ground activities should be included using a variety of noises, signal to noise ratios, and degrees of reverberation to simulate the difficult listening conditions of most classrooms. Children also need training to monitor their own speech production and to attach meaning to environmental sounds.

Paterson (1982) stressed the need to train students to use prosodic information such as stress and intonation to interpret meaning. Such cues are available to most profoundly deaf students using proper amplification. Children may be taught to differentiate between questions, statements and commands, to recognize differences in meaning conveyed by word boundaries and how syllables are stressed. Prosodic information also conveys affective state. Paterson suggests the use of role plays to teach these concepts.

Auditory skills should be taught in meaningful contexts such as routine daily activities. For example, discrimination of soft and loud sounds can be taught within the context of a cooking activity and accompanied by appropriate language input (Robbins, 1990; Erber, 1982). Some established auditory training curricula are too narrow in focus, requiring children to listen in restricted contexts, with limited response choices, and with limited use of language and speech skills (Robbins, 1990). Ling (1986) points out that unless auditory training activities occur in meaningful contexts, children will view them simply as exercises and not generalize skills to communication situations in real life.

Some form of assessment must be part of all curricula and intervention programs because deaf and hard of hearing children have a wide range of skills and needs. Individualized

programming must be based on assessment of skills. Erber (1982) proposes that auditory detection, discrimination, identification and comprehension skills be assessed with a variety of speech stimuli including speech elements, syllables, words, phrases, and sentences.

Speechreading is an integral part of normal speech perception and is important in production. Therefore, speechreading training should be integrated with auditory skill and speech production development. Some training activities should be unimodal (auditory or visual), while others should be bimodal (audiovisual). The current trend is toward increased bisensory training to facilitate integration of auditory and visual cues.

Edwards (1991) presents principles which should be considered in the development of skills within auditory training curricula:

1. There must be a clear need for acquisition of the auditory skill within the child's environment.
2. There must be opportunity for the child to practice ans use the skill in a variety of situations.
3. The child must be able to perform the skill in life-like activities.
4. There must be sufficient reward for appropriate use of the skill.

Activities may be analytic or synthetic in nature. Analytic training, also called "bottom up", uses a step-wise approach from detection to discrimination, using drill-type procedures, to closed set identification to open set identification to comprehension. There is some question about the value of drill-type detection and discrimination activities for improved identification and comprehension of speech needed for everyday listening situations (Doehring and Ling, 1971; Erber, 1982). Listening for meaning requires learning environments where acoustic cues may be combined with contextual and situational information (Doehring and Ling, 1971; Erber, 1982).

There is some contention that analytic auditory training is important for speech production. However, authorities agree that learned analytic skills must immediately be used in meaningful language context for generalization to occur (Cole & Paterson, 1984; Erber, 1982; Ling, 1976; Paterson, 1982).

Synthetic approaches, also called "top-down" or language based, focus on sentences or connected discourse in meaningful situations and stress conversational interaction. Erber

(1982) describes a Natural Conversational Approach that may be used in class throughout the day. The teacher speaks to the child naturally without visual cues, focusing on whatever auditory skill level (eg. discrimination, identification) is appropriate for the child. If, despite situational and contextual cues, the child does not respond appropriately, the teacher uses a remedial strategy that involves presenting the same material using a lower level auditory skill. For example, the teacher might ask a child to identify a picture in a book; if the child is unable to respond, the teacher might repeat the request using a discrimination format such as "Is this picture _____ or _____?"

Erber (1982) describes a second synthetic approach that he calls "Moderately Structured". Identification and comprehension training follow a classroom activity, using vocabulary appropriate for that activity and language structure appropriate for the language level of the class. The Experience Story exemplifies this approach. After the teacher and children talk about an activity, the teacher writes a series of descriptive sentences on the board using language elicited from the children. This language is then used for identification and comprehension activities.

Erber (1982) also describes his concept of "adaptive communication" which may be used for analytic, natural conversational, or moderately structured approaches. It involves expansion which is used if a child is able to perceive speech with no difficulty at a particular level of vocabulary and syntactic complexity. The teacher substitutes new vocabulary or more difficult language structure. If, on the other hand, the child experiences difficulty with the task, a remediation approach is used. The teacher might repeat, clarify or emphasize the original presentation, substitute more familiar vocabulary or simpler language, move to a lower level response (eg. discrimination rather than identification), or use visual cues in addition to auditory.

A program or curriculum can include both analytic and synthetic activities. Analytic training can be used during individual therapy to remediate specific weaknesses or provide auditory support for speech production activities. Synthetic activities can be integrated into the classroom curriculum and individualized using adaptive communication. An optimal training program should include both bottom-up and top-down activities

Criteria and Guidelines for MMT

The following guidelines and criteria are based on the intervention principles discussed in the previous section:

1. Auditory training programs should include activities to develop skills in the following areas: detection, localization, selective attention, memory/sequencing, discrimination of suprasegmental and segmental speech features, closed-set and open-set identification of speech and environmental sounds, comprehension, figure-ground skills, voice monitoring, and use of suprasegmental information.
2. Both analytic and synthetic activities should be included, but the focus should be on language based activities.
3. Discrimination training, especially of non-linguistic materials, should be minimized.
4. Auditory training activities should be integrated with language training, speech production, and speechreading. Some activities may be unimodal but audiovisual integration should be a priority.
5. Activities should be interactive, meaningful, and intrinsically rewarding.
6. All training should incorporate expansion and remediation strategies, as needed.
7. Curricula and programs should include assessment procedures and provide individual programming.
8. Real life situations should be used or simulated.

Hearing Aid Orientation

All auditory training activities are predicated on the proper use of hearing aids. In order to use hearing aids well, children need the continuing and consistent support of teachers and parents who are knowledgeable about their benefits, limitations, use, care, and maintenance. With this support, children can assume increasing responsibility for the use and care of their hearing aids as they become more mature.

Hodgson (1986) describes the components of a good hearing aid orientation program. It should include:

1. Development of realistic expectations and positive attitudes toward hearing aids.
2. Understanding of how hearing aids function.

3. Ability to operate hearing aids:
    a. insert, replace, and care for batteries
    b. adjust the volume control
    c. properly use the telecoil
    d. insert and care for the earmold
4. Ability to perform a daily visual and listening hearing aid check. The Ling 5-sound test is widely used for this purpose. It involves listening to an appropriately adjusted hearing aid while speaking three vowel and two consonant sounds. The Child is then asked to respond to the same 5-sounds while wearing the hearing aid (Ling, 1976).
5. Ability to troubleshoot malfunctions such as absent, intermittent, or weak sound, loudness which does not change smoothly as the volume control is manipulated, noise or distortion in the hearing aid, and feedback.
6. Ability to help the young child accept and properly use the hearing aid.

Many researchers have evaluated hearing aids that children bring to school, and have found a high incidence of malfunction (Diefendorf and Arthur, 1987; Kemker, McConnell, Logan, and Green, 1979; Potts and Greenwood, 1983; Hanners and Sitton, 1983; Bess and McConnell, 1981; Elfenbein, et.al., 1986; Busenbark & Jenison, 1986). A number of studies have shown that direct parent and teacher training using lectures, demonstrations, sound/slide programs, and videotapes resulted in significant reduction of hearing aid malfunction (Foust and Wynne, 1991; Deifendorf and Arthur, 1987; Hanners and Sitton, 1974). A workbook entitled "Orientation to Hearing Aids (Gauger, 1987) has been found useful for these programs.

Sanders (1982), Berliner & Eisenberg (1985), Davis & Hardick (1981), Von Almen and Blair (1989) recommend that deaf and hard of hearing school children also receive information about effects of hearing loss on communication, hearing aids, and assistive listening devices. Hearing aid orientation objectives and activities should be part of auditory training curricula

Assistive listening devices, primarily FM systems, are used in many schools. Orientation to these systems is similar to hearing aid orientation. In addition to the need to understand benefits and limitations, proper use and care, and trouble-shooting procedures, parents,

teachers, and children need to become comfortable with the following special features of FM systems:

1. Importance of keeping the FM microphone no more than 6 inches from the talker's lips.
2. Importance of recharging the batteries in the transmitter and all receivers each night by correctly placing the equipment in the charger.
3. Importance of making sure that the teacher's transmitter and the child's receiver are on the same channel which is different than the FM channel used in other classrooms. When changing classes, either the child or the teacher must take responsibility for changing the channel on the receiver.
4. The teacher must learn for which classroom activities FM is suitable. For example, FM is appropriate when the children are being taught as one group; however, it is not appropriate when the children are working in small groups on different activities.
5. FM signals can be transmitted through walls up to a distance of 200 to 300 feet depending on the strength of the system. Therefore, the teacher must remember to turn off the FM transmitter when it is not being used.

Search of the literature revealed no research on orientation to assistive listening devices nor descriptions of orientation programs. There is a need to incorporate objectives and activities on orientation to FM in school curricula and a need for studies evaluating the benefits of such training.

Review of Auditory Skills Media and Materials

Many auditory skills curricula and hearing aid orientation programs have been developed by residential and public school programs for deaf children (eg. Kendall Demonstration Elementary School, Fairfax County, VA). In addition to curricular materials, programs for parents, teachers and older students, designed to improve use of amplification in the classroom, are available (Gauger, 1987; Hanners & Sitton, 1974, and Nussbaum, 1988). Most of the auditory skills curricula follow the model described by Erber in his book entitled Auditory Training (1982). This book is a excellent general reference on development of auditory skills. A few of the auditory skills curricula have been disseminated outside of local

school districts and are used around the country. Some have served as prototypes for local programs. Several of the better known curricula are described and critiqued in the following section.

Auditory Skills Curriculum

One of the most widely used programs is the Auditory Skills Curriculum which is part of the Auditory Skills Instructional Planning System (Los Angeles County Superintendent of Schools, 1976). This curriculum was developed for and standardized on over 800 deaf and hard of hearing children from ages 3 to 12 with a wide range of sensorineural hearing losses. types of amplification. The children used various types of amplification, and attended total communication, oral, residential and mainstream education programs.

The curriculum is divided into four major areas: discrimination (includes detection and attention), memory-sequencing, figure-ground (difficult listening conditions), and auditory feedback (use of audition for speech production).
Within each area, long term objectives (called terminal performance objectives or TPOs) are presented in order of difficulty. For each TPO, there is a sequential series of short term objectives (called intermediate performance objectives or IPOs), leading to successful completion of the long term objective. The IPOs are directly measurable because they are stated in behavioral terms and are accompanied by criteria. Activities are presented for each IPO.

Goals and activities follow the developmental model of auditory skills and are sequenced from easy to difficulty based on linguistic redundancy and acoustic similarity of stimuli within a discrimination task. Early activities focus on suprasegmental features, and as skills are developed, increased emphasis is placed on segmental features.

The practice materials for each IPO are referenced to the educational level of the student (eg. preschool, primary, etc.) and teachers are encouraged to develop variations, supplementary activities, and individualized objectives as appropriate. Language level and content of the activities can reflect academic curricula and social communication. There is a preschool supplement designed to meet the needs of deaf and hard-of-hearing children from birth to four years. All activities are presented first in a multisensory mode (signs,

speechreading, audition). Visual cues are gradually reduced until the child is successful in the auditory mode. Familiar material may be initially presented in the auditory mode, with remedial strategies applied if the child has difficulty.

The Auditory Skills Curriculum may be used with the Test of Auditory Comprehension (TAC) to suggest the starting place in the curriculum for a child. As an alternative, the child may be placed on the curriculum by assessing IPOs sequentially in each curriculum area until appropriate levels are found.

Developmental Approach to Successful Listening (DASL)

The DASL was developed for deaf children from age 2 through secondary school. It is designed to be used in individual therapy sessions rather than in the classroom. The program is highly structured and analytical, involving a hierarchy of auditory skills. The steps between subskills are very small, minimizing difficulties children might experience moving from one objective to the next. The activities for the subgoals are games, designed to motivate the child. The games and the language can be individualized so that the activities can be used at any age or language level.

Three areas of auditory skills are included in the curriculum. Sound awareness includes care and use of amplification, detection, localization and selective attention. Auditory comprehension includes various levels of discrimination, memory/sequencing, identification and comprehension. Phonetic listening skills help children use their hearing for speech production, thus integrating speech production with auditory skill development. After successfully completing the curriculum, a child may work on any of the subskills in a background of noise or competing signal. Subskills from different sections of the curriculum may be developed concurrently after the child has completed basic goals in the Sound Awareness section.

A DASL Placement test is included with the program. Its function is to identify where the child should begin in the different areas of the curriculum.

Critique

The Auditory Skills Curriculum and the DASL provide goals and activities in the areas of selective attention, discrimination of supra-segmental and segmental features, identification, comprehension, and figure-ground differentiation. Although the Auditory Skills Curriculum follows the normal developmental pattern of auditory skills, little time is spent in development of basic skills such as detection; hearing aid orientation is not included at all. School curricula based largely on the Auditory Skills Curriculum (Auditory Skills Curriculum, Fairfax Co. VA., 1984; Auditory and Speech Training Curriculum Guide, Kendall Demonstration Elementary School, 1988) have recognized these deficiencies and have incorporated objectives and activities on detection, localization, selective attention, and hearing aid orientation. The DASL, in contrast, deals well with basic level auditory skills and hearing aid orientation.

Both curricula include goals for voice monitoring and use of hearing for speech production, thereby integrating speech production and auditory skill development. The Auditory Skills Curriculum stresses audiovisual integration, and provides for the strategies of remediation and expansion. The DASL deals exclusively with auditory skills.

Although both programs present activities in sequential order of difficulty, the steps between short term objectives are much smaller in the DASL. Because goals and objectives in both curricula are presented in several areas concurrently, it is possible for a child to work on more than one skill at the same time. Both programs provide assessment procedures.

Both curricula are applicable to a wide range of functional language levels. Although both programs are language based, they include analytic or bottom-up approaches. The DASL is more analytical than the Auditory Skills Curriculum which makes it less suitable for classroom activities but more suitable for computer programming. Neither curriculum is suitable for a natural conversational or language experience approach. Real life situations are not simulated.

Non-curricular materials

There are a number of books on the market containing auditory training activities for children (Sanders, 1993; Lowell and Stoner, 1960, Berg, 1978). Some, like the Lowell and

Stoner materials, are designed for young children and use games for activities. Other books present activities for a range of ages.

Berg's Listening Handbook (Berg, 1978) contains activities which develop a fairly comprehensive range of auditory skills. Even though each lesson includes several different skill areas, there is no clear hierarchy of skills or presentation of objectives in a progression from easy to difficult. The importance of reciprocity between listening training, speech production, and language training is stressed, but there are no specific procedures or activities to implement such integration. There is no attempt to simulate real life situations. Other materials suffer from the same problems. These programs cannot be considered curricula, but many of the activities can be incorporated into curricula and adapted for interactive computer presentation.

Micro Sound Product.. has produced a set of four CD-Rom compact discs which contain 314 environmental sound and noises for use in training auditory awareness and identification. Included are sounds of the workplace (eg. construction sites), the household (eg. running water), restaurants, sports (eg. bowling), transportation (eg., cars, planes), etc. These materials can be purchased from: Micro Sound Products, 555 Bryant Street, Suite 249, Palo Alto, CA 94301.

Cochlear Implants

Increasing numbers of deaf children, age two and older, are using cochlear implants. They require follow-up aural rehabilitation, primarily in the form of audiovisual training. The Nucleus 22 cochlear implant, approved for children by the FDA in June 1990, is the only system being used for children. The cochlear implant consists of external components which may be removed and internal components which are surgically implanted. The external components consist of a microphone worn at the ear connected by a cord to a speech processor worn on the body. The speech processor is connected to a transmitter held in place behind the ear with a strong magnet. The internal components consist of a receiver implanted in the mastoid process and magnetically aligned with the external transmitter. The receiver is connected to an array of 22 electrodes (channels) implanted in the inner ear.

After the healing process is complete, the external components are fitted and each of the 22 channels is programmed so that the electrodes respond to the softest possible sounds and are set for maximum comfortable listening level. The program, called a MAP, is incorporated within the speech processor. After the MAP has been established, training begins.

Candidacy Issues

In order to assure maximum benefit from a cochlear implant, candidacy criteria must be carefully applied. Criteria for children and adults were recommended at a Consensus Development Conference at NIH in May 1988 and are being used by the vast majority of cochlear implant teams, particularly with child candidates. These selection criteria are summarized by Black (1988) and Tye-Murray (1993).

Age 2 is accepted as the minimum age for implantation for the following reasons: a) hearing status must be established prior to surgery and ability to benefit from amplification ruled out. It is very difficult to make those determinations at younger ages; b) rapid head growth may still be occurring, which may cause an implanted electrode to dislodge; c) young children are more prone to middle ear infection than older children; d) the young child may be unable to participate in the programming process, necessary for the fitting of the implant. Some teams require that a child have learned the conditioned response to tactile stimulation prior to cochlear implant surgery.

Candidates must have profound, bilateral sensorineural hearing loss and should receive minimal benefit from amplification. Typically pure tone thresholds are no better than 95 dB and the candidate is not able to recognize words auditorily. Aided thresholds are no better than 60 dB.

Parental commitment and realistic expectations are essential. Extensive counseling, stressing the fact that the child will continue to function as a severely hearing impaired individual, is performed. Some cochlear implant teams seek commitment of the child if he or she is old enough to understand the process.

Availability of rehabilitation services is a crucial factor. Most cochlear implant teams make a strong effort to assure that the child's educational program includes development of

auditory-oral skills. The child may be enrolled in a total communication program provided the program makes at commitment to auditory skill development and speech production.

Training Principles

Auditory training procedures with a cochlear implant are similar to those used with children who wear hearing aids. According to Osberger (1986) training should be balanced between discrete listening activities using structured lessons and more global practice in the context of regular classroom activities.

Moog and Geers (1991) emphasize that instructional objectives for discrete listening training should be based on the normal developmental model of auditory skills. The appropriate training level for a child should be determined by evaluation of auditory skills. The DASL (Van Ert Windle and Stout, 1986) is being used by many cochlear implant programs for analytic auditory training. Moog and Geers recommend that as a child acquires specific auditory skills through individual training, they should be reinforced through classroom activities using a natural conversational or language experience approach (Erber, 1982). For young children, toys and games should be used for activities.

McConkey (1990) agrees that it is desirable to begin training with discrete activities which should be complemented by a natural language approach to insure carryover of learned skills to real world situations. However, a conversational approach may be too challenging to a child who is just being introduced to sound or who is learning a new auditory skill; therefore, an intermediate level of training should be used for transition. Strategies to accomplish this transition include increasing size of the response set, introduction of time delay between explanation of task and presentation of stimulus, presentation of stimulus when the child is not in a "listening set", moving gradually from an identification to comprehension response, and introduction of some kind of distraction.

Stroer (1992) defines the goal of cochlear implant training as development of specific analytic and synthetic auditory and speech skills within the context of language and concept learning. Auditory activities are designed to develop perception and identification of environmental sounds as well as speech. The Ling speech program (1976) and a variety of materials developed for auditory and speech training with hearing aids, including DASL, Auditory Skills Curriculum, are used.

Brackett (1991) stresses that all training activities should include both speech perception and speech production components. Audiovisual training and appropriate communication strategies should be included in the cochlear implant training program especially since speech comprehension through audition alone is not realistic for all implant users (Tyler, Tye-Murray, and Lansing, 1988).

Speech tracking (DeFilippo and Scott, 1978) is recommended at the elementary school level using audiovisual input, speechreading alone, and in some cases audition alone. The teacher reads phrases or short sentences from an appropriate narrative. The child is required to repeat verbatim. To resolve communication breakdowns, the teacher uses a variety of communication strategies such as speaking more expressively, isolating a missed word, changing the timing, paraphrasing, defining the word, reviewing the phrase, or anything else appropriate. Boothroyd, et al (1988) developed computer tracking lessons for children over age 7 and adults, using laser video disk technology. Seventeen short stories, spoken by a female talker, are used.

Orientation to the cochlear implant, use, care, trouble-shooting, and development of realistic expectations are essential aspects of cochlear implant training for parents. Parents, teachers, and older children need to be able to perform a daily visual and listening check of the cochlear implant, analogous to what is done with hearing aids. In order to do so, they need to become familiar with how the system functions, how to connect the external components, how to position the transmitter behind the ear, and how to check the settings of the speech processor.

Criteria and Guidelines

1. Both analytic (bottom-up) and synthetic (top-down) programs are needed. Specific stimulus response, natural conversational, and transitional activities should be included.
2. Audiovisual training, with appropriate communication strategies, should be part of all curricula.
3. Auditory and audiovisual activities should be integrated with speech production activities.

4. Curricula should include incorporation of discrete training goals into classroom activities.
5. Materials are needed to help families and children develop realistic expectations of benefits.
6. Materials are needed to help teachers, parents, and older children learn proper use, care, and troubleshooting of cochlear implants.

Two excellent general references on all aspects of cochlear implants are: Cooper, H. (Ed.), (1991). Cochlear Implants, A Practical Guide and Tyler, R. (Ed.), (1993). Cochlear Implants, Audiological Foundations.

Review of Media, Materials, and Technology

There is little technology, media, or materials developed specifically for cochlear implant training. Most training programs use materials developed for auditory training with hearing aids. The only cochlear implant training curriculum found in the literature was developed by Cochlear Corporation (1992). Although it was designed for adults, the format and many of the actual exercises are suitable for elementary and secondary level students. Some activities can be adapted for younger or language limited children by modifying the language.

Cochlear Corporation Curriculum

The Cochlear Corporation curriculum is divided into four levels, with overlap between levels to facilitate transitions. The goals span the hierarchy of auditory skills from detection to comprehension. Within each level, activities range from easy to more difficult. If a client experiences difficulty with an activity, the same material is presented at a lower auditory skill level. Auditory and audiovisual activities are incorporated into the curriculum. Screening tests determine the beginning level of training appropriate for a child.

An activity called paragraph tracking is used. The teacher reads a paragraph appropriate for the language level and interests of the child. The child follows along using a written copy of the paragraph. If the child falls behind, the teacher repeats the last word or uses other strategies until the communication breakdown is resolved. The teacher may slow the reading

rate or move to more complex materials, depending on the responses of the child. Tracking as an intervention technique will be discussed more completely in a later section of this synthesis.

Telephone training is an integral part of the curriculum. Depending on the capabilities of the child, it includes identification of telephone signals, development of a yes-no telephone communication code, familiarization with common phrases, number identification, role plays involving telephone conversations of varying degrees of difficulty followed by actual phone calls, and telephone repair strategies

Computer software is available as part of the curriculum for some of the analytic vowel and consonant analytic training.

Critique

This curriculum includes analytic and synthetic materials presented in a hierarchy of skill levels. It may be used for auditory training with hearing aids as well as with cochlear implants. Many of the activities, particularly at the comprehension level, are language based and applicable to life situations. The curriculum uses the concept of adaptive communication, allowing the child to easily move back and forth between levels. Audiovisual training, communication

strategies, and telephone training are included. The major deficiency of the program is that it was not specifically developed for children. Although some of the activities can be easily adapted for elementary and secondary school children, such adaptation cannot be done as easily for younger children.

Parent and Teacher Guides

The Cochlear Corporation has published a Guide to the Mini System 22 for parents of deaf children who are being considered for a cochlear implant and another manual for teachers and other professionals who work with implanted children. Both manuals cover the following topics:

1. How the cochlear implant functions
2. Candidacy issues
3. Training to use the implant

4. Benefits, limitations, and factors influencing success
5. Use and care; checking and troubleshooting the system
6. Educational concerns: use in the classroom, use of FM with the implant, parents as advocates, parent-teacher partnerships

The manuals contain lists of materials, organizations, and other resources.

Captioned videotapes are available, including one in which four families of implanted children discuss the impact of the cochlear implant on their lives.

Critique

Both guides are well written at appropriate levels for their target audiences. The parents' manual is encouraging but realistic in discussing benefits and limitations. Clear informative illustrations, understandable technical information, and practical use, care and troubleshooting procedures are included in both manuals. These manuals are available only through Cochlear Corporation, distributor of the Nucleus 22 cochlear implant. Similar manuals, targeted to a wider audience, might be useful.

Speechreading and Communication Strategies

Speechreading: Intervention Principles

According to Yoshinago-Itano (1988) there are three approaches to the teaching of speechreading. The traditional bottom-up approach focuses on the visual aspects of phonemes and phoneme combinations; the student practices on syllables and then progresses to identification of words, sentences, and connected discourse (Bruhn, 1949; Bunger, 1944; Kinzie & Kinzie, 1931; Nitchie, 1950). The holistic top-down approach focuses on connected discourse using real-life situations and language. It does not include drill on phonemes, syllables, isolated words or sentences. The interactive approach is primarily a top-down system but teaches identification of the visemes of speech as well (a viseme is a group of phonemes, such as /p,b,m/ which look alike on the lips).

Speechreading programs for children tend to be holistic in nature. Lessons are based on simulated real life situations and experiences using language which is familiar and within the

competence of the child. Drills are not used. When the language of the speechreading lesson and the language of English class are similar, speechreading can reinforce English language instruction (Jacobs, 1982). Simulated real-life situations used with younger children revolve around interaction with parents, siblings, and peers. The focus for older children is on social situations and communication within the school environment. Speechreading training should be integrated with instruction in communication strategies that the child can use when speechreading is insufficient for clear communication. Ability to identify articulatory movements may make it easier for a child to "fill in the blanks" of an ambiguous or incompletely understood message.

A hierarchy of speechreading activities should be established, starting with easy tasks and gradually increasing the difficulty. Parameters that can be varied in difficulty include: signal/noise ratio, number of talkers, brightness and direction of lighting, amount of visual distraction, familiarity of the talker, familiarity of the topic and vocabulary, and complexity of the language. Easy materials include: familiar stories such as nursery rhymes, child-generated materials such as language experience stories, language based on topics of interest such as sports or TV programs and familiar commands, greetings, and directions.

Speechreading training should occur primarily in an audiovisual environment because audiovisual communication is more typical of conversational conditions than communication which is solely visual (Erber, 1974).

Communication Strategies: Intervention Principles

Training to use communication strategies is an integral part of the language and situation-based holistic approach to speechreading. Children need to develop a repertoire of anticipatory strategies to prevent communication breakdown and repair strategies to resolve communication breakdown. Before any strategies can be used effectively, the child must learn to function assertively. This involves recognizing that the message was not understood, informing the communication partner of the problem in a polite manner, and explaining how the communication partner might facilitate communication.

Anticipatory strategies include identification of:

1. Words and sentences that might be used in a forthcoming situation. This vocabulary is then used for speechreading practice;
2. Sequence of topics and probable talkers in a forthcoming situation;
3. Environmental factors that might create difficulty (eg. noise, multiple talkers), and ways of dealing with them;
4. Talker variables that can be improved by advanced planning. The child might be able to request slower speech, clearer articulation, simpler shorter sentences, some indication of when a topic change occurs, or the use of an assistive device). (Tye-Murray, 1993)

Repair strategies are behaviors a child can use during a communication interaction such as asking a talker to repeat, rephrase, simplify or indicate the topic of a message. Additional repair strategies include asking for the spelling of a word, using code words for letters not understood (eg. "b" as in boy), asking for numbers one digit at a time, asking specific questions, and writing a misunderstood message. To keep communication flowing, a child should always confirm what is understood.

Children should be trained to use repair strategies expressively as well as receptively. Elfenbein (1990) points out that communication breakdown can occur because children's poor articulation and language skills interfere with understanding of their speech. Many of the same strategies that are useful receptively (eg. rephrasing, writing, simplifying) can help clarify communication when the child's speech is not understood.

Conversational strategies used for turn-taking, changing topic, and terminating a conversation often need to be taught. The child needs to become familiar with the cues that signal these behaviors (eg. topical change may be cued by longer pauses between utterances).

Training programs should focus on strategies that are relevant to the child's real life communication needs, that children are willing to use and that do not require enormous effort. Selection of specific strategies for training should be prioritized based on what is required in the classroom environment and what the child feels he or she needs. Children must be able to understand how to use a strategy. A communication strategies training program should include assessment tools such as role plays, tracking exercises, questionnaires, and

communication scales to determine which strategies the child uses and which need to be learned. Tye-Murray (1993) stresses the need for research to determine which communication strategies are needed by children, which strategies deaf and hard of hearing children are able to use, and which strategies other children can comprehend.

Training activities should be motivating to the child. They should be well-defined and usable by teachers in a variety of educational settings. Strategies may be taught through workbook exercises, conversations and role plays with classmates or with the clinician in individual sessions, and real world practice. Within a classroom situation, both teacher and children must learn to use strategies. Edwards (1991) indicates that during the first two to three years of school, the teacher is likely to initiate most of the strategies, but by third grade the child often has sufficient cognitive and linguistic skills to do so.

There are a number of instructional techniques which can be used in the classroom (Palmer, 1988). These include role plays of identified difficult situations, conversational practice using starting, stopping, topic change, and turn taking rules and routines, use of appropriate assertive behavior for resolving simulated conflict situations, and role reversals. It is helpful to videotape and play back role plays so that a child and peers can evaluate and make suggestions for improvement. Videotapes featuring high status individuals (eg. peers or parents) using strategies successfully in simulated real life situations may be used for modeling. After these classroom techniques have been used successfully, children can practice learned skills in real life situations.

Connected discourse tracking is an excellent technique to use for teaching of speechreading and strategies (DeFilippo, 1988; DeFilippo & Scott, 1978). Tracking is self-paced, provides a synthetic, language-based approach to speechreading and strategies training, allows instant feedback, can be used visually, auditorily or audiovisually, and emphasizes use of communication strategies to resolve communication problems. It is an interactive procedure, allowing for modification of task difficulty as needed. The age-appropriateness of tracking depends on materials and procedures used, language competence and attention span of the child. Erber (1978-1979) reported successful tracking with 11 to 15 year old severely and profoundly deaf children; Goldberg (1988) reported use of auditory tracking with two three-year old children.

Connected speech is presented by the clinician, one phrase at a time. The child is asked to repeat, word for word, what is said. When errors occur, either the talker or the receiver use various communication strategies to resolve the communication breakdown. The number of words correctly identified per minute may be calculated.

The original procedure of DeFilippo & Scott (1978) required verbatim repetition and use of a hierarchy of strategies by the talker with the final strategy a "fail-safe" behavior such as writing or signing. Many clinicians develop their own hierarchy of strategies to meet individual needs. Instead of using talker initiated strategies, the child may be required to request strategies when misunderstanding occurs (Owens & Telleen, 1981). Several authorities (Owens & Raggio, 1987; Tye-Murray and Tyler, 1988) suggest the use of gist rather than verbatim repetition to better simulate real life conversation.

Reverse tracking is designed to facilitate the child's use of expressive strategies to improve his or her own speech intelligibility. This procedure requires the child to read a passage; the clinician repeats every word or the gist of the message. When an error occurs, the child must initiate repair strategies to resolve the communication breakdown.

If the child is having difficulty, material can be simplified or different strategies used. It is possible to allow the child to have a copy of the test and follow along as the teacher reads aloud. If desirable, the teacher can make the activity more difficult by increasing length of utterance or changing presentation conditions.

A variety of talkers should be used for tracking activities. They should be trained when to pause, what types of strategies to use, how to provide effective reinforcement, how to speak clearly, how to provide good body language, and what to do if unable to understand the child's responses.

Selection of material for tracking activities is important. Materials must match the language competence and interests of the child. Pictures may be needed to maintain interest and can be used as reinforcement. Popular sources of material include children's reading development series, articles in magazines, newspapers, digests, and literary works for children, and high-interest, low language level materials. It is also possible for the child and/or the teacher to generate materials (eg. story about a recent experience).

Pre-tracking activities can facilitate tracking with children. One strategy involves breaking down a difficult word in a tracked passage into its individual speech elements. In order for a child to use this strategy, he or she must be taught relationships between spoken or mouthed phonemes and a symbol system (eg. Northampton Charts), how sound sequences are blended to form words, and spelling and pronunciation rules. Other pre-tracking activities include reading the passage before the tracking activity, practicing key words and proper nouns used in the passage, and providing clues such as the topic, title, or first line of the story.

At this time there are no materials or curricula developed for use of connected discourse tracking with children.

Criteria and Guidelines

1. Speechreading training for children should be primarily language-based, using simulated real life experiences.
2. It should occur primarily in an audiovisual environment although visual activities may be incorporated as needed.
3. Analytic activities involving discrimination between or identification of articulatory movements can be beneficial.
4. Speechreading curricula should provide a hierarchy of activities gradually increasing in difficulty. Parameters which can be manipulated include auditory and/or visual noise, familiarity of talker, familiarity of material, complexity of material.
5. Materials should be within the language competence and interests of the child. It is beneficial to use materials related to classroom activities.
6. Speechreading and communication strategies training should be integrated.
7. Children need training in assertive behavior, anticipatory strategies involving talker, environment, and message variables, and repair strategies.
8. Repair strategies should be used expressively to clarify the child's speech intelligibility as well as receptively.
9. Conversational strategies used for turn taking, topic changing, initiating and ending conversations should be taught.

10. Specific strategies taught should be relevant to the child's communication needs, should be understandable to the child and be easily usable by the child.
11. Assessment procedures should be available to determine which strategies the child knows and uses.
12. Strategies training should be usable by teachers in a variety of educational settings.
13. Instructional techniques should include role plays, conversational practice, workbook activities, and practice in real life situations. Videotaping is useful for evaluation and critiquing of a child's performance and for modeling of successful use of strategies.
14. Connected discourse tracking can be used with any age child if the material is suitable and the child's language competence and attention span are sufficiently developed. Reverse tracking can be helpful to the improvement of speech intelligibility.
15. Age and language appropriate materials and curricula are needed for connected discourse tracking for children.
16. Interactive video programs can be useful for both speechreading and communication strategies training.

Review of Media and Materials

As with auditory skills materials, most school systems have developed their own speechreading and communication strategies curricula, but few have been disseminated. A notable exception is the material that has been developed by the Outreach unit of the Gallaudet Pre-college programs. Several of these programs are reviewed in the following section.

Speechreading in Context (Deyo and Hallan, 1984) is a program which provides functional speechreading activities for deaf children in elementary school. A synthetic approach is used, with emphasis on understanding of meaning; there are no drills on syllables or individual words. Materials are presented in order of difficulty. The activities may be used as a framework for development of others. Adaptive teaching strategies are used as needed.

Topics that are covered include greetings, school vocabulary, endings and transitions (eg. see you later, time for lunch, bye-bye), common comments (eg. please, thank you, I'm sorry),

commands and questions, and conversations. Each lesson begins with practice of teacher and student generated words and phrases based on discussion of the topic. This is followed by a role play, after which the same format is extended to related situations.

This program is relevant and real life oriented. It can easily be integrated into the classroom curriculum. The major disadvantage is that it focuses only on speechreading and does not include auditory or communication strategies training. This program could easily be adapted to interactive computer videodisc technology.

The Kendall Demonstration Elementary School Auditory and Speech Training Curriculum Guide (Nussbaum, et al, 1988) has been published and disseminated. It includes auditory skills, speechreading, and speech production objectives and activities for deaf and hard of hearing students at preschool through junior high school levels. The curriculum is designed to be used by teachers in classroom situations but can also be used for individual therapy. It is based on a communication philosophy in which auditory skills, speechreading and speech training are infused throughout the daily routine and as much as possible within the classroom. Activities tend to simulate real life situations; role plays and mimes are used especially for training communication strategies.

Learning objectives are arranged according to increasing level of difficulty. In the development of auditory skills, material is introduced in a multimodal manner (signs, speechreading and audition) and visual clues are gradually faded out. In the development of speechreading skills, signs and auditory clues are gradually faded out. Response choice sets are increased from 2-choice options to open set. Familiarity of materials gradually decreases. Speechreading training follows a hierarchy from discrimination and identification of single words in structured communication situations to comprehension of connected discourse with and without clues. Included are activities to develop awareness of mouth movements and facial expression.

A section of the curriculum deals with development of attending skills, repair strategies, and conversational strategies for turn taking, attracting the attention of a person, initiating, maintaining and ending conversation appropriately. Students are taught that appropriateness of strategies depend on whether a person is hearing or deaf and on the context of the situation.

This curriculum is interactive, integrates skill areas, focuses on daily life and classroom situations, uses adaptive strategies, presents objectives in a hierarchical manner, can be used with any age child, and is applicable to oral, sign language and cued speech programs.

Communicate With Me: Conversation Strategies for Deaf Students (Deyo and Hallau, 1988) is a program designed to help deaf students improve their ability to gain a person's attention, take turns, initiate and end conversations, select appropriate communication methods, select appropriate topics, change topics, and use repair strategies. Although the program was designed for students with hearing loss, it can be used for all students with special needs.

A pre-test is given at the beginning of the curriculum to determine the appropriate units for that student. Pre-tests and post-tests are included with each unit and a post-test occurs at the end of the program. Each unit follows a similar format, starting with learning when and how to use the strategies and continuing with role plays and subsequent discussion. Additional age related enrichment activities are included

The program is highly synthetic, using real life situations that are appropriate for elementary school children. It is highly motivational because of the role plays. Each unit is well structured, moving from didactic teaching of behaviors to practice in simulated situations. Evaluation is built into the program at the beginning and at selected points throughout the curriculum.

The real-life situations could lend themselves nicely to videotape presentation similar to a format developed for adults by Trychin and Boone (1987). A vignette is presented in which a communication rule is violated, resulting in communication breakdown. The students identify the behaviors that caused the problem, role play correct behaviors and explain why they are correct. They then view the next portion of the videotape which shows the correct way of handling the situation. This program is discussed further in the paper on English Language Development and Refinement.

Elfenbein (1992) developed a program to teach repair strategies to children, ages 7 to 14. The program includes:

1) Understanding of the communication process and the many different modalities through which communication can occur;
2) Identification of the signs and causes of communication breakdown using role plays and videotapes of interactions;
3) Formulation of a socially appropriate message based on information to be transmitted and characteristics of the sender, receiver and situation;
4) Introduction of repair strategies and practice in role plays within the therapy room, assignments within the clinic, and in real world situations. Interactions within the clinic are videotaped and critiqued.

Throughout the program, children have the opportunity to discuss their feelings and frustrations about their attempts to repair communication breakdowns.

Twenty five children were evaluated after completing six weeks of the communication strategies program. All of the children demonstrated better matching of strategies to situations, and use of a greater variety of repair strategies. Although this program has been designed for use in a clinical situation, it can be adapted for the classroom.

Interactive Video for Auditory, Speechreading and Communication Strategies Training

Interactive video is inherently motivating to a child because tasks are usually programmed in the form of games or activities which provide immediate feedback. It usually provides drill and practice as a supplement to classroom instruction to facilitate habituation of newly acquired skills. Although many of these programs tend to be analytic in nature, there have been attempts to develop real life simulation activities. For example, Tye-Murray, Tyler, Bong, & Nares (1988) have developed simulations of activities in the life of a hearing-impaired student.

Computer technology provides the versatility to control complex protocols tailored to individual needs. It makes possible an interactive learning situation in which successive stimuli are determined by the child's previous responses. The rate of instruction is dictated by

students' skills and learning styles. A clinician need not be present and training can be scheduled at times convenient to students.

According to Smaldino and Smaldino (1993, optimal aural rehabilitation is based on a multidimensional model in which different aspects of training occur concurrently and interactively; therefore, cornputer programs should facilitate interaction of different skill areas. A range of stimuli (eg. simple overlearned utterances to longer more complex sentences) and a variety of response formats (eg. multiple-choice closed set task and open-set identification tasks) should be available. Programs should allow for change in presentation parameters based on the response of the child (eg. increase or decrease of response set, use of strategies). Random access and computer controlled branching capability are required for such individualized instructional activities.

Computers and videotape players are available in most educational facilities; however, videodisc equipment is less common, possibly because of the high cost of developing a videodisc master. Still, the type of interactive programming needed for effective training in auditory skills, speechreading, and communication strategies requires videodisc technology.

Both software and hardware should be user friendly. It should be easy for a chi'd to respond (eg. touchscreen). Programs should be easy for teachers to use. Ideally, it should be possible for the teacher/ clinician to modify the software to individualize the program to meet students' needs. However, it is probably unrealistic to expect the majority of classroom teachers and communication therapists to have adequate programming skills to make such modifications.

Ijsseldijk (i992) provided information about optimal video images for speechreading activities, use of stimulus repetition, and rate of presentation by evaluating these parameters on 33 orally trained prelingually deaf children between 8 and 16 years of age. The conclusions of the study were that full face and profile images are most useful for videodisc presentation, and that a lips only presentation mode is not useful. Repetition helps speechreading performance and should be made an option with every exercise. Exercises using slower presentation rates do not seem to be helpful.

Only three interactive computer programs designed for children were identified. These are discussed in some detail. Other programs have been developed for adults. Several are discussed briefly because of the possibility of modifying them for children.

Programs for Children

Tye-Murray (1993) developed a laser videodisc program for children ages 5 to 15 which combines auditory training, audiovisual training, and use of two repair strategies to clarify a misunderstood spoken message. This program has been published in book form to make it more accessible to educational facilities.

The program consists of 25 lessons, each focusing on a specific set of consonants. Each lesson presents syllable, word, and sentence activities in sequential levels of difficulty dealing with sound awareness, same/different discrimination, closed set word recognition, open set word recognition, closed set sentence recognition, and sentence recognition based on a key word clue. The teacher/clinician has the option of increasing the size of the sets in any of the lessons. Lessons are ordered so that the sounds within the consonant vowel syllable and word exercises become increasing difficult to discriminate or identify by audition only. Sentences relate to common life occurrences.

Response options in the form of pictures appear on the screen after each stimulus is presented. Students respond by using a touchscreen. All stimuli are presented in the audiovisual mode first. When the student is successful with a prescribed number of stimuli, the activity continues in the auditory-alone mode. Various strategies are available to the teacher to simplify an exercise if necessary. In addition to auditory and audiovisual training, the key word strategy and the strategy of repeating the stimulus sentence as confirmation of understanding are taught.

The second computer program is the **Interactive Training System for Listening (ITS-Listening)** developed by Carolyn Brown (1992). This program targets speech discrimination and identification skills at the phoneme, syllable, word and sentence levels, providing training in pattern perception and speech discrimination based on suprasegemental and segmental features. There are no synthetic comprehension exercises. The tasks are presented

sequentially from easy to difficult. The program contains pre-testing, post-testing, and practice tasks as well as training exercises.

The system is interactive; a child's response on a task determines the specific task that follows. Tasks may be repeated for more intensive practice. Stimulus content and presentation mode (eg. auditory or audiovisual), may be modified to meet individual needs. In addition to 450 pre-programmed lessons, there is a lesson editor to allow the teacher to individualize the exercises for each child.

The program can be used with children of all ages. Games are incorporated into the lessons for younger children. Responses are made using a touchwindow with pictures as response prompts.

Tye-Murray, Tyler, Bong, and Nares (1988) developed three videodisc programs to train speechreading and assertive communication.

The goal of Program 1 is audiovisual consonant speechreading training using consonant vowel syllables, single syllable words, and words embedded in carrier phrases. Response prompts on a touchscreen consist of different colored circles for the consonants and pictures for the words. A male and female talker present the stimuli. A stimulus along with a visual reinforcer (eg. smiling face) is presented first in a discrimination mode and then in a closed-set identification mode. Incorrect responses result in repetition of the stimulus, while a correct response produces a smiling face. These activities can be used for auditory training by turning off the visual image of the talker.

Program 2 provides synthetic audiovisual speechreading training and development of communication strategies. One of ten talkers presents a sentence accompanied by four pictures. The student responds by touching one of the pictures. If the response is not correct, the student may select one of five repair strategies. The procedure continues until the sentence has been identified correctly.

Program 3 provides situation-specific speechreading training, using eleven exercises based on home and school situations (eg. breakfast, bus stop, classes). First the child views a 10 second film clip establishing the setting. Then a talker appropriate to that setting presents sentences audiovisually in closed-set format similar to that used in Program 2. If the child's response is incorrect, repair strategies are selected until the sentence is correctly identified.

Some of the talkers deliberately create difficult communication situations (eg. chew gum, make noise).

Critique

All three programs integrate vision and audition. All the programs are interactive and modify presentation of stimuli based on student responses. They provide options and strategies that allow the teacher/clinician to modify the ease or difficulty of the exercises. Objectives and activities are presented in a hierarchy of easy to more difficult tasks.

The Tye-Murray programs teach repair strategies. However, neither one includes evaluation procedures; the ITS-Listening program does. The Tye-Murray programs attempt to relate sentence materials to real life situations, and one of the 1988 programs includes real life scenarios. The ITS-Listening program makes no attempt to include synthetic activities related to life situations. The content of the activities in the Tye-Murray programs cannot be altered because there is no provision for teacher modification of the software. The ITS-Listening program does provide a lesson editor, allowing a teacher or therapist with programming skills to make individual adaptations.

Adult Programs

The Dynamic Audio Video Interactive Device (DAVID) program (Sims, 1988) provides speechreading drill materials dealing with familiar expressions and job-related sentences. Depending on level of performance, a student uses a multiple choice, fill in the blanks, or open set format. Materials can be presented with or without sound. The student can request repetition or clues about sentence content.

The Auditory-Visual Laser Videodisc Interactive System (AVIS) (Kopra, Dunlop, Kopra, and Abrahamson, 1985) was developed for postlingually deaf adults. It consists of five to eight word sentences presented in order of speechreading difficulty. Each sentence is presented a maximum of 5 times, with each presentation accompanied by different auditory or visual clues.

Computer Assisted Tracking (CAST) (Pichora-Fuller and Cichelli, 1986) is a tracking program developed for adventitiously deaf adults. It consists of paragraphs, each loaded with

a particular viseme. The speechreader views the paragraph in its entirety for orientation, then types each phrase as it is viewed. The computer provides feedback, displaying the correct portion of the response and leaving blanks for misidentified words. The student has the option of asking for replay of the phrase or going on to the next phrase in hopes of using context clues to identify the initial one. The program allows for the inclusion of other communication strategies. After a maximum of ten trials on a phrase, the missing words are filled in. The program provides positive reinforcement for a good guess based on identification of a homophenous sound. The clinician can select the rate of speech, and decide whether to use audiovisual or visual replays. Various types of scoring are included in the system.

Video Laserdisc Test and Training Battery Arthur Boothroyd (1988) developed a series of six half hour laserdiscs for children, age 7 and older, and adults. These materials can be used for auditory and audiovisual speech perception testing and training. The battery includes a range of training materials at phoneme, word, and sentence levels: a) the **Thrift**: detection of suprasegmental and segmental speech pattern contrasts in a varying phonetic context within nonsense syllables; b) the **Spac**: identification of suprasegmental and segmental speech pattern contrasts in a varying phonetic context within words and phrases; c) identification of CVC words; d) sets of topic related sentences emulating conversation; e) 17 short stories that can be used in a variety of ways, including continuous discourse tracking. The training materials are interactive, providing feedback and repetitions as needed. Motivation and successful completion of tasks are enhanced.

Telephone Training

Many deaf and hard of hearing children need to learn how to use the voice telephone or the TTY (also called TDD or TT). Such training includes auditory skills, language, speech intelligibility, communication strategies, assistive devices, and informational counseling. Specific objectives involve:

1. Finding the best way for a child to use the voice telephone with or without the hearing aid, with or without telephone amplifiers, using the microphone or the telecoil

of the hearing aid. It is necessary to determine the preferred ear for telephone use, find the best position of the telephone receiver or supplementary amplifier relative to the hearing aid, and teach proper use of the hearing aid telecoil;

2. Listening training, including telephone signals, specific numbers, names, prerecorded messages, role plays of frequent conversations, telephone conversations with the teacher, and actual phone calls to friends and strangers;
3. Use of anticipatory strategies to structure a conversation and prevent anticipated difficulties and receptive and expressive repair strategies. The child needs to identify talker conversational features which create difficulty and aspects of his or her speech which create problems for a communication partner;
4. Speech production activities to improve the intelligibility of the child's speech;
5. Development of an intensity pattern code for children who cannot conduct open set conversations on the telephone. Children must structure their conversations so that the communication partner can respond by saying "no, yes-yes, or I don't know". Such conversations are used only for specific prearranged communication. For all other purposes, the TTY is used;
6. Information about the telephone and TTY, including how to dial, what to do if the line is busy or if a wrong number is dialed, how to use an answering machine, and use of relay systems;
7. Language training to structure a conversation using correct vocabulary and grammar on the voice phone or TTY;

(Erber, 1982, 1985; Castle, 1980).

Training should progress from easy to difficult activities. Therefore, there should be a range of materials varying in familiarity and complexity, and an array of conversational practice ranging from face to face conversations using prepared scripts to telephone conversations with strangers. Teaching activities include role plays with and without prepared scripts, listening games, tracking via telephone, and use of prerecorded messages.

Media and Materials

Although several telephone training curricula have been developed for adults (Castle, 1980; Erber, 1985), only one curriculum for children has been identified in the literature. Ring Flash (Deyo and Hallau, 1984) is a comprehensive TTY and voice telephone training program for elementary school deaf and hard of hearing children. It provides sequential learning, practice, and evaluation activities in a series of units. Didactic instruction, prerecorded messages, role plays, and a hierarchy of practice situations are used.

Unit 1 teaches use of TTY, including how to use the equipment, keyboard skills, TTY abbreviations, how to send a clear message, how to use repair strategies. Unit 2 deals with the voice telephone, providing training and practice with sound signals, code systems, repair strategies, and listening practice with single words, familiar phrases, and sentences and various levels of conversation. Unit 3 teaches use of the telephone directory. Unit 4 involves rules of telephone etiquette such as proper ways to answer the telephone, identify oneself, handle wrong numbers, tell a person to hold, and verify a phone number. It also includes how to plan a conversation, respond to an answering machine, and the importance of allowing time for a person to answer a call (particularly when using the TTY). Unit 5 deals with accessing operator assistance, particularly for locating phone numbers and connecting phone calls.

Critique

Ring Flash covers most aspects of telephone training in a sequential fashion at a proper level for elementary school students. It contains many activities relevant to daily life which could be adapted to interactive video programming. The Repair Strategies section can be used for training not related to telephone use. A major deficiency of this curriculum is that it does not contain objectives or activities for improving speech intelligibility on the telephone. Also, the curriculum was developed before the advent of telephone relay systems and therefore does not contain training to use them. Since third party relay systems have become an important telephone communication mechanism, the curriculum needs to be updated to include this type of training.

Media, Materials, and Technology Needs

Conclusions and Recommendations

Auditory skills curricula should cover a hierarchy of auditory skills based on the accepted developmental model. Although bottom-up and top-down activities should be included, the focus should be on language based objectives and activities using real life situations. Auditory training activities should be integrated with speechreading, speech production and language training. All activities should be interactive, provide for individual adaptation, and allow for expansion and remediation strategies as needed. All curricula should contain objectives for orientation to hearing aids and assistive devices as well as assessment procedures.

Although most schools for deaf and hard of hearing children have developed auditory skills curricula, several of which have been disseminated, for the most part these curricula use a bottom-up approach. There is a need for synthetic, language and situation based programs suitable for natural conversational or language experience approaches in the classroom using materials that are suitable for the language competence and interests of a wide range of children. Simulated or actual real life situations need to be utilized to a much greater extent that currently exists.

Although most auditory skills curricula contain hearing aid orientation objectives and activities, there is a notable absence of orientation and training materials for assistive devices and cochlear implants. Such materials are needed for teachers, parents, and children who use the systems. Although training activities are similar to those used for hearing aid users, there are differences primarily in the areas of use, care, troubleshooting, adjustment to the listening system, and development of realistic expectations. No assistive devices curricula were identified for children or adults. Only one comprehensive cochlear implant curriculum for adults (Cochlear Corporation curriculum) was found and this is not readily available to schools. Comprehensive training programs incorporating top-down and bottom-up objectives are needed for children, teachers and parents, particularly for cochlear implants.

Speechreading programs for children should also be primarily language based, using meaningful real life experiences. Speechreading should be integrated with auditory and communication strategies training. Programs should include training in assertive behavior

and conversational strategies. Although several top-down curricula have been developed and disseminated by the Pre-college programs at Gallaudet University, there is need for additional curricula incorporating a synthetic, interactive, integrative focus.

Connected discourse tracking is an excellent activity for developing speechreading, audiovisual, and communication strategies skills. It can also be used to improve the intelligibility of a child's speech. There is need for development of age and language appropriate tracking materials for children.

Interactive videodisc technology can be used for auditory skills, speechreading, and communication strategies training. It is interactive, highly motivating, can provide immediate feedback, and can individualize instruction by tailoring stimulus presentation to the child's responses. Tye-Murray and colleagues have developed several videodisc programs for children which contain both analytic (bottom-up) and synthetic (top-down) programs. There is need for additional programs which focus on real life situations. Much of the printed curricular materials, including tracking activities, can be adapted to video technology.

Voice telephone and TTY training involve auditory skills, speech production, language skills, communication strategies, use of assistive devices, and informational counseling. Although several curricula have been developed for adults, only one program for elementary school children has been identified. This program does not contain speech production activities nor instruction in use of third party relay systems. Telephone training curricula, in print and interactive video form, are needed for children.

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ENGLISH LANGUAGE DEVELOPMENT AND REFINEMENT

By Mary June Moseley, Ph.D.

Introduction

This section of the synthesis will discuss needs of deaf and hard-of-hearing children in the development and refinement of the English language. Emphasis will be on the use of language for interpersonal and functional communication. Additional language areas, such as reading and school curriculum areas (e.g. social studies and drug education, etc) are beyond the scope of this review.

In this section of the synthesis language will be defined and current models of language development presented. The existing research in English language characteristics of children with hearing loss will then be summarized, as well as principles of language curriculum development. Methodology used for examining media, materials and technology (MMT) will be described and current MMT discussed. Finally, recommendations for program development and limitations of this paper will be addressed.

Definitions/Models

Language is defined as "....a socially shared code or conventional system for representing concepts through the use of arbitrary symbols and rule-governed combinations of those symbols" (Owens, 1992, p. 4). This socially shared code allows the exchange of information between two individuals, which is a part of the larger process of Communication: "...the process of exchanging information and ideas between participants". (Owens, 1992, p. 7). Communication includes a linguistic code and several different means of transmission, such as speech, intonation, gestures, and body language. The linguistic code may be received and expressed through several modes: speech and listening, signing, writing and reading.

In order to be able to effectively use the linguistic code of English, the language learner must have knowledge of and expertise in several different areas of language (Lund & Duchan, 1993; Owens, 1992):

Semantics (meaning). e.g. vocabulary, nonliteral language such as idioms and humor (figurative language), similarities and differences in words.

Syntax and morphology (word order/grammatical information): e.g. phrase structure, clause structure, sentence types (question vs. declarative), form word classes (nouns, verbs, adjectives, pronouns etc.)

Phonology (sounds). e.g. production and perception of sounds, use of paralinguistic features (stress, intonation, etc.).

Pragmatics (use). Using language appropriately. This involves three different aspects:

1) Communicative intentions - the ability to get or give information from/to the environment. For example, a speaker uses language to give information about objects and people, to direct other's actions, to express feeling, to promise or pledge to do some action.

2) Discourse rules - the child must learn the conventions of conversations in order to communicate. For example, he/she must be able to initiate a topic of conversation, maintain that topic, close the conversation, take turns with a conversational partner, and repair the conversation when breakdown occurs.

3) Taking the perspective of the receiver - a speaker must provide sufficient information to a conversational partner to assure understanding of the message. For example, the speaker must be aware of differences between conversational partners and choose language appropriately, based on the age and role of the receiver and the degree of shared information between the participants. This is frequently accomplished in English by the use of cohesive devices (Halliday & Hasan, 1976), words which tie sentences together, e.g. pronouns which are used to refer to a previously stated person or object (Judy is my friend. She is coming to visit).

A current model of the English language development process explains the young child's acquisition of the above areas of language within a framework of communication of wants and needs. The Interactionist perspective indicates that the form of language (syntax, morphology, semantics, phonology) may develop primarily through use, that is experiencing the immediate environment with a primary caretaker. The caretaker helps the child focus on objects and actions in the environment, providing a framework for taking turns acting upon and talking about immediate events. This occurs through natural play and daily routines and is a consistent on-going process. This framework provides an opportunity for the child to

learn the pragmatics of language through the turn-taking process while language form is presented through talking about experiences in which joint action and reference is maintained by the child and caretaker. As the child reaches school age, complexity of language form continues to develop through use and natural interaction (Lund & Duchan, 1993; Owens, 1992).

It is this current model of language acquisition and the areas of language form described above that will be discussed in this synthesis in relation to the development of media, materials and technology for children with hearing loss.

Research in English Language Characteristics of Children with Hearing Loss.

The child born with a hearing loss is at a disadvantage from birth in learning English through natural interaction with the environment and caretakers. Lack of auditory input provides incomplete access to the form of language and may effect the ease with which pragmatic aspects of English are learned, thus effecting communicative ability.

There has been limited success in developing English language in deaf children well enough to serve as an adequate vehicle for educational development, regardless of the language modality used (Quigley & Paul, 1984). This paper, however, will not discuss the controversy over what form of language (oral or signed) should be taught to young deaf children. The purpose of this paper is to summarize the available research data describing the specific areas of semantics, syntax and pragmatics that appear to be effected by hearing loss. The area of phonology (speech sounds) will be described in a later section of this synthesis.

Although the above areas are treated separately for purposes of description, it must be emphasized that they are not learned or used separately, but coexist in the process of using language to communicate. When children do not learn language on their own in naturalistic surroundings, language & communication programs need to be designed to encourage the integrated acquisition of its various aspects (Nelson, 1993). The following studies focus on the development of oral-aural and written language skills in children with hearing loss.

Semantics. The first words of young deaf children (whether signed or spoken) appear to be similar to those of their hearing peers (McAnally, Rose & Quigley, 1987). They learn words representing important people in their lives (e.g. mamma, daddy), objects they can

manipulate (e.g. sock, shoe) and objects and actions whose movements are easily identified (e.g. cat, dog, open, hop). However, vocabularies of young deaf children may contain fewer lexical items than those of hearing peers. They tend to have difficulty with English function words and less knowledge of common content words (McAnally, et. al., 1987).

Figurative language is crucial to communication in English, both verbally and in writing. Estimates are that figurative language may constitute as much as two-thirds of spoken and written materials (Boatner & Gates, 1969). The most common forms of figurative language are metaphors, similes, and idioms, most requiring the ability to determine similarities and differences between various attributes (McAnally, et.al., 1987).

Hearing children who exhibit problems learning the English language demonstrate difficulties in figurative language (Abkarian, Jones & West, 1990; Wallach & Miller, 1988), as do children with hearing loss (McAnally, et. al. 1987). Clinical evidence supports the needs of deaf and hard-of-hearing children in this area, particularly in the use of idioms (Hughes & Kuerbis, 1985; McAnally, et. al, 1987).

Syntax. In the area of development of oral English syntax, the research indicates that deaf and hard of hearing children appear to develop similarly to hearing children, although at a slower rate (Kretschmer & Kretschmer, 1978; Quigley & Paul, 1984). They move from one-word to two word phrases, then to subject-verb-object sentences.

Much of the research in the area of syntax has been with written language. Quigley & his associates (Quigley, et.al., 1977; Quigley & Paul, 1984) have extensively studied written syntax with deaf and hard of hearing children, ages 10-18 years. They have identified specific syntactic structures that are problematic: the verb system, negation, conjunction, complementation (problems with infinitives), relativization, and question formation. In addition, students appear to use a subject-verb-object sentence pattern for all types of sentences. Difficulty in writing sentences translates into difficulty in producing clear written discourse.

Pragmatics. There is little research to describe the use of communicative intentions with deaf and hard of hearing children. There is some indication that deaf pre-schoolers use similar expressions of intentions as do hearing children (Pien, 1985). Although there is little research on the use of discourse rules by children with hearing loss, this area is perceived by

experienced teachers as problematic for some deaf children (Brackett, 1983; Nichols, 1993). Specific areas cited as difficult are topic maintenance, appropriate topic choice and repairing conversational breakdown.

In addition, there is little research showing how children with hearing loss take the perspective of the receiver, provide information to a listener and if they do so easily. This area is important to evaluate in children with hearing loss, particularly the use of cohesive devices (DeVilliers, 1988; Kretschmer, 1989). Cohesive devices are the words that tie sentences together in discourse. They include syntactic forms such as pronominalization, conjunction, relativization, temporal adverbs (e.g. before, now, then), ellipsis (e.g. a partial sentence: "..on the table", typically used in response to a question), articles, and synonyms (Kretschmer, 1989; Lund & Duchan, 1993).

Pronominalization, conjunction and relativization are syntactic forms that were mentioned in the discussion of written syntax as problematic for children with hearing loss. These forms are necessary to provide sufficient information in discourse for understanding. There is some indication that this area may also be problematic in oral English discourse. Hughes & Moseley (1988), found that five college-age students with hearing loss demonstrated problems with ellipsis, relativization and use of articles.

The above characteristics are not all inclusive nor are they present in every individual with hearing loss. Research needs to be continued to examine the variety of different areas that are necessary for communication competence and to determine the specific characteristics found in specific individuals with hearing loss.

Principles of Language Curriculum Development.

Using the model previously described in this paper, the following principles underlying communication curriculum development for children with hearing loss were described in the Report of the Second National Workshop on Language Curriculum Development for Students with Hearing Loss in Australia (Power & Hollingshead, 1982).

1. "Communication experience begins from the earliest moments of life. Communicative competence is intertwined with and dependent upon cognitive and social development.

2. The child's attempts at communication should be valued when meaningful, irrespective of the "correctness" of their form.

3. Linguistic competence includes phonologic, syntactic, semantic and pragmatic features. Communicative competence includes linguistic, non-linguistic and para-linguistic features. All these features of language and communication should be an interrelated part of the school communication curriculum.

4. Initially, ...children (with hearing loss) should acquire language through a normal mother-child interaction model (conversational approach). If a child of school age is assessed as having a significant language delay, this conversational approach should be supplemented by systematic teaching based on principles of normal language development.

5. The curriculum must concurrently provide the following situations in which language acquisition can occur:
   - conversation
   - task oriented activities (in which language development is secondary to the activities themselves)
   - specific language teaching (in which activities are secondary to language development...)

6. The child's current linguistic competence is the starting point of any language program, and this competence needs to be continuously and systematically monitored by an adequate evaluation program.

7. A curriculum should involve a dynamic process in which the child actively participates. Since language is acquired through use, child-based activities and first-hand experiences should be the major vehicle for development.

8. Phonological and syntactic development depend entirely on a firm foundation of meaning (semantics).

9. Given that language is best acquired in meaningful situations with competent models, opportunities should be devised (both within and outside the classroom) to widen access to authentic interactions with a variety of people, taking into consideration a child's level of competence and confidence.

10. Language has a variety of uses for communicative functions and different forms may be used to express the same functions when situations and communication partners

vary, just as different functions may on some occasions be expressed by the same form. It is important that children acquire these pragmatic features of language." (Power & Hollingshead, 1982, pp. 5-6).

In summary, these principles indicate that children with hearing loss need to be given continuous opportunities to participate and use language through communicative interaction with others in their environment. At the same time, they may need assistance in refining specific areas of language.

This model for curriculum/program development is consistent with other ones used in the field of Speech-Language Pathology for hearing children with language delays: for example, McLean & Snyder-McLean (1978) discuss a transactional approach, Owens (1991), a functional approach and Nelson (1993), an integrated system. This approach has been encouraged for deaf and hard-of-hearing school children (Bonnickson, 1985; Hodgens, 1982; Hollingshead, 1982). In addition, a model for Aural Rehabilitation with adolescents and adults proposes integrative communication therapy centering on functional communication and specific area refinement (Wilson, et.al., 1990). These principles are applicable for individuals of all ages, from infancy through high school.

Inherent in these principles is the inclusion of other communication skill areas. For example, auditory skills, speechreading skills, speech and voice, sign communication, and technology all must be considered for a complete program, as well as the language areas discussed in this section of the synthesis.

Specific questions to be asked in this synthesis about language materials and technology.

1. What kinds of materials and technology are being used by professionals to develop and refine English language use in children with hearing loss?
2. Do the existing materials and technology meet the criteria of the principles of intervention described above?
3. How can new materials and technology best meet the needs of children with hearing loss?

Methodology

Several methodologies were used in identifying programs and technology used with children with hearing loss.

1. An computerized ERIC search was conducted. The following key words were entered in various permutations: hearing impaired, language, software, deaf, program, computer assisted instruction, software. The computer search identified appropriate responses from January, 1982 through December, 1992.
2. Specific journals were further examined for pertinent articles published since January, 1982. They were: The Volta Review, American Annals of the Deaf, Journal of Speech & Hearing Research, Journal of Speech & Hearing Disorders, Language, Speech and Hearing Services in Schools, Journal of Computer Users in Speech & Hearing.
3. Selected individuals, who have current contact with deaf children, were contacted to discuss types of programming used.

It is clear from additional review of reference lists and publishing catalogues that many printed and technological materials purport to deal with language. The review of materials in this paper is not intended to be all-inclusive, but to include those that are most commonly used and that demonstrate program diversity.

Materials reviewed in this synthesis are representative of the available programs that are used by or recommended by Speech-Language Pathologists. There has been no attempt to examine reading curricula, or other language materials that may be important for teaching content information in classrooms for deaf and hard-of-hearing children.

Printed Language Materials/Programs

Parent-Infant Programs. The use of programs designed for infants with hearing loss and their parents has become an important part of education and speech-language services. Bruce (1986) surveyed 55 parent-infant programs to determine the materials that they used. Of the respondents, approximately 61% of the programs used the SKI*HI materials designed at the University of Utah (Clark & Watkins, 1985).

The SKI*HI program was the result of twelve years of research, development and experience. It is a holistic approach to home programming for hearing impaired children and

their families and includes screening, referral and diagnosis as well as family training. The home visit curriculum includes: parental readiness, psycho-emotional support for families, planning and reporting home visits, hearing aid program, communication program, auditory program and language stimulation program (with parental choice of either aural-oral or total communication). (Clark & Watkins, 1985).

The home communication program focuses on information to be given to the parents. It includes information which emphasizes the importance of communicative interaction; how an infant learns to communicate and what signals are important for communication; why and how a child communicates; aspects of parental communication such as speech adjustments mothers make when they talk to their children (motherese); the importance of interaction and conversation; and reinforcement. In addition, communication mode, aural-oral or total communication is discussed in order to help the parents make informed decisions about the mode best suited to the family and child (Clark & Watkins, 1985).

The home communication program also includes skill lessons for parents which emphasize three areas:

1. Establishing an effective communicative setting by minimizing background noise, encouraging the child to explore and play, serving as a communication consultant by encouraging the child as he/she plays and explores, using interactive turn-taking, getting down on the child's level, maintaining eye contact and directing conversation to the child.

2. Establishing effective non-verbal communication by use of facial expressions, intonation, natural gestures and touch.

3. Establishing effective verbal communication by responding to the child's cry, stimulate babbling, identifying and responding to communicative intents, using conversational turn-taking and using meaningful conversation.

The Home Language Stimulation Program is based on the following fundamental language assumptions:

1. Language involves the interaction of: (a) content - what a child communicates, (b) form - how a child communicates, (c) use - why a child communicates.

2. Natural parent-child interactions and conversations are the processes for language development.

3. Normal language development should be the basis of the content of the program.

4. Language behaviors are an essential means of assessing language levels and progress. (Clark & Watkins, 1985)

The Aural-Oral portion of the stimulation program focuses on skill levels designed to do the following:

1. Use conversation in four language areas: child care activities, parent task activities, child initiated activities, and parent directed activities.

2. Select appropriate target words and phrases: vocabulary related to the specific experiences and needs of the individual family.

3. Increase use of target words and phrases.

4. Reinforce child's expressive language.

5. Expand child's language attempts.

6. Maintain naturalness. (Clark & Watkins, 1985)

The curriculum goals, as stated, meet many of the principles of program development as described earlier in this paper, providing language in a natural context. A positive feature of the language stimulation program is the ability to modify the specific lessons to meet the needs of individual families. Flexibility to provide for individuality is inherent in the concept of "naturalness". In addition, provision of the needs of culturally different clients (Damico & Damico, 1993) can be accommodated through a program such as SKI*HI.

The early research done at Utah suggests that the SKI*HI provides effective ways to work with parents (Clark & Watkins, 1985). Research into the efficacy of this program is continuing. Data sheets are provided to parents and professionals to help track the progress of the child and the parents. These data are submitted once a year to the Evaluation Research Center at the University of Virginia, for ongoing analysis (Clark & Watkins, 1985). However, no published results of this longitudinal data were identified in the search conducted for this paper.

There is a need for programmatic research in the field of deaf education and such research should play an active role in the development and use of new materials (Moores, 1985).

Current discussion regarding the "best" way to help young deaf children develop a language base, questions the desirability of providing an English oral-aural program to children with severe hearing loss (Johnson, Liddell, & Erting, 1989). Since little research is available to show longitudinal progress in any type of developmental program, continued research and evaluation of existing and newly developed programs is essential.

The Bruce survey, identifying parent-infant program resources, did not specify what materials were used by the programs not using SKI*HI (39% of the programs). In her article, Bruce does list 10 additional resources appropriate for parent-infant programming: 40% of those materials were related to infant development, but not specific to hearing loss (Bruce, 1985).

Programs for School-Age Children. Several individuals have undertaken surveys to examine the kinds of instructional language materials used with deaf and hard-of-hearing students in schools (King, 1984; Power & Hollingshead, 1982; Takemori & Snyder, 1972; Wathum-Ocama, 1992).

Takemori and Snyder (1972) surveyed representing ten schools for the deaf in the United States, and found 30 different types of printed materials which were quoted as being used by the language teachers. Only seven were designed for deaf children and only three of those were specifically designed at schools for the deaf for each school's population. Respondents to the survey worked on English language through the written mode, using creative writing and correction of written English syntax as major methodologies. Takemori & Snyder concluded there is a basic need for materials designed for children with hearing loss that would assist teachers in working with written English.

King (1984) conducted a national survey to determine methods used to teach English to children with hearing loss. Of 233 responses, most preschool programs described their instructional approach as natural (emphasis on colloquial and idiomatic language) or a combined approach using natural and structural (the study of grammar and syntax) methods. Programs at the higher levels, primary, intermediate, junior high and high school used fewer exclusively natural approaches and more structural approaches. It was not clear whether oral or written grammar and syntax was emphasized. Both of the studies, however, appear to

emphasize that teachers are emphasizing specific skill areas, particularly syntax and grammar, at the school level.

More recently, Wathum-Ocama (1992) surveyed instructional language materials used in programs for deaf and hard-of-hearing students. Sixty-seven percent of the 68 respondents indicated the biggest problem was finding available age and interest-appropriate materials. Forty-three percent of the respondents noted a lack of emphasis on appropriate skills, although these skills were not defined. Sixty percent of the individuals surveyed designed their own language materials, while 37% cited the Apple Tree program as their instructional language guide (Anderson, Boren, Caniglia, Howard & Krohn, 1975). The Apple Tree program emphasizes use of syntax and grammar (King, 1984; Power & Hollingshead, 1982).

The conclusion could be drawn from the above surveys, that many language materials used with deaf and hard of hearing school-age children are materials relating to specific areas, with particular emphasis on syntax and grammar. In the following section, several issues related to specific teaching areas will be discussed.

Specific Areas. Syntax and grammar programs frequently involve identification of subjects, verbs, pronouns, nouns, etc. Such identification of language elements constitutes metalanguage: language used to talk about language (King, 1984). Children's awareness of the structural aspect of their language and thus, the ability to talk about language, appears to develop around six-seven years old and continues through the elementary school years (Smith & Tager-Flusberg, 1982). For this reason, careful attention must be given to the suitability of specific area programs in the area of syntax for use with young school children.

Power & Hollingshead (1982) make several recommendations for the use of specific area teaching programs. They indicate that preschool children and some children with very limited linguistic competence may not be ready for specific teaching approaches, and that specific teaching not make up a significant portion of the school day. They encourage integration of specific areas with each other and with regular curriculum and classroom interaction. Following is a discussion of selected programs related to specific area teaching.

The Test of Syntactic Abilities (TSA) (Quigley, Steinkamp, Power & Jones, 1978) is a diagnostic kit with a parallel teaching program, TSA Syntax Program (Quigley & Power, 1979-81). The TSA is based on a 6 year study of children with hearing loss 10-18 years of

age. The test evaluates nine different syntactic areas: negation, conjunction, question formation, pronominalization, verbs, complementation, relativization, disjunction & alternation (Quigley, Power, Steinkamp, 1977).

The program provides a set of materials representing each of the nine areas. Interactive activities for teaching the structure are presented, as well as specific Workbooks for each aspect of the structure, to be used as follow-up activities (Power & Hollingshead, 1982). In accordance with the interactive principles described earlier, the activities are seen as the primary teaching/learning core of the program. Students are presented with a variety of sentences with different meanings, but having the same underlying structure. The intent is to encourage the student to deduce the rules of the grammar. According to Power & Hollingshead (1982), the program addresses three of the specific areas of language: semantics, syntax, and pragmatics (through the interactive teaching methods). They further indicate this program may be used as a model for the development of other materials suited to the specific needs of the students being taught.

This program relies on reading and writing and is recommended for use with children ages 10 and above. The syntactic structures that are presented in this program are also relevant for learning the use of cohesion and can be used for specific written discourse teaching. It appears this program does combine several language areas, while emphasizing syntax. Although the TSA itself was developed after extensive research on children with hearing loss, no journal articles were found which addressed the success of the teaching methods accompanying the evaluation tool.

It is clear from a review of publishers catalogues that vocabulary and figurative language programs do exist, but this search did not identify any specifically designed for children with hearing loss. Power & Hollingshead (1982) indicate the existence of few specific programs in the area of semantics which are designed for children with hearing loss. They further recommend the development of programs which take into account cultural factors, interest level, and represent current experience. Their guidelines infer the need for flexibility in programs designed to teach vocabulary and figurative language to children with hearing loss.

Nippold, Schwarz, & Lewis (1992) suggest the following guidelines in the development of figurative language programs for hearing children who have difficulty in this area: 1)

Comprehension of figurative language improves gradually throughout childhood, adolescence and into adulthood, therefore, children should not be expected to master many different figurative expressions in a short amount of time. 2) Comprehension appears to improve when figurative expressions are presented in meaningful and supportive contexts. For example, children generally find proverbs more difficult than metaphors, similes or idioms. Lessons should gradually move from easier to more complex tasks. McAnally, et. al. (1987) indicate the need for activities based on recognizing similarities and differences between various attributes, since most figurative language is based on comparison. These guidelines are consistent with some of the principles for programming described earlier.

Specific areas of pragmatics. Learning the rules of conversation is one aspect of pragmatics, as defined in the beginning of this paper. Deyo & Hallau (1983) developed a program entitled Communicate with Me: Conversation Strategies for Deaf Students. The purpose of this program which focuses on student-to-adult interactions, is to help deaf students improve their conversation skills. It includes seven units covering the following areas: 1) selecting appropriate topics and communication methods, 2) gaining attention, 3) turn-taking, 4) ending conversations, 5) repair strategies, 6) maintaining and changing topics, 7) combined practice areas from all units.

The Communicate with Me program was designed for students 7-15 years old. The program uses role-play activities, visuals in the form of pictures, cards and books, as well as checklists for rating self or others through video-tape analysis. The stories in the books and the pictures represent every-day life situations encountered specifically by deaf students. For example, one of the role-play activities describes a situation in which the student must approach a deaf principal, begin a conversation about selling copies of the school newspaper and then end the conversation (Deyo & Hallau, 1983)

This program addresses a specific area of language within a conversational format. In addition, it provides pictorial representation of the activities as well as discussion. The use of visual/pictorial design in instructional materials for children with hearing loss is desirable (Diebold & Waldron, 1988). The stories and pictures are relevant to experiences of deaf children. The flexibility of this program provides the potential for integrating other areas of language (e.g. semantics, pragmatic intentions, etc.) into the existing lessons

No written evaluation of the Communicate with Me program is identified. However, a similar program, using role-playing and video analysis, was tried for 18 weeks with 12-13 year old deaf children in Queensland (Murphy & Hill, 1989). The focus of this program was on communicative function and included initiating and maintaining conversations, as well as specific functions such as asking a favor, how to cope with being teased, how to make polite queries, etc. Analysis of this program indicated improvement and awareness of the skill being facilitated as well as generalization to other spontaneous interactions.

There was no evidence of specific programs designed for working with the pragmatics of taking the perspective of the receiver. However, there is informal clinical support that teaching the use of cohesive devices in English is effective in providing for the needs of the receiver in verbal English as well as written English (Hughes & Moseley, 1988).

Technology

Trachtenberg (1986) discussed applications of computers in working with deaf children. She divided computer usage into three major areas: 1) The computer as tutor. The tutor mode is often referred to as Computer Assisted Instruction (CAI) and usually involves a programmed presentation of subject material, student response, evaluation of student response and determination of what to present next. 2) The computer as "tool". In this mode, the computer is used as a word processor, a data base that has been programmed to organize and retrieve materials, or a calculator or spreadsheet. 3) The computer as a "tutee". In this mode, the student or teacher must learn to program the computer.

Larson & Steiner (1985) discuss the use of the computer as tutor and tool, indicating that in addition to drill, practice and tutorials, the computer may be used for: 1) simulation of situations related to real-life; 2) instructional games which sharpen note-taking abilities, ability to follow directions, hypothesis testing, and cause-effect relationships; 3) problem-solving activities permitting users to divide tasks into small steps; 4) exploration and discovery, where the user can pose questions, make decisions, and solve problems.

Rose & Waldron (1984) conducted a survey of microcomputer use in programs for children with hearing loss. Microcomputers were used by 51% of the 342 programs surveyed. Seventy percent of the computer use described by the respondents was CAI, which

they defined as involving drill and practice. Tutorials, defined as the presentation of materials and questions to students, were also used.

Technological innovations have led to the use of the videodisc which provides capability for random access to materials on the disc. This allows educational programming where students can learn to locate specific learning sequences. In addition, the interface of videodiscs and computers can to create visual material which interacts with dialogue (Withrow, 1981).

More recently, technology has moved in the direction of more interactive teaching through what is known as hypermedia learning. According to Jensen (1993), hypermedia learning: "....entails interactive and nonlinear navigation through learning material that reaches students' senses --seeing, hearing, touching, smelling" (Jensen, 1993, p. 8). Clymer (1991) further defines hypermedia as the use of date, text, graphics, video, and voice as components in a hypertext system with all the various forms of information linked together so that a user can easily move from one to another. The key factor in this learning is the joining of broad-band networks where a computer may be in one state, learning materials in another and groups of learners located at different areas around the country. This type of multimedia networking encourages social interactions and provides a promising avenue for language learning. (Jensen, 1993).

Principles for integration of CAI into language programming.

The computer search for this synthesis did not yield articles evaluating the use of CAI, specifically software programs, for children with hearing loss. However, an analysis of publishers catalogues and discussions with speech-language pathologists confirms a plethora of programs designed for teaching aspects of the English language to hearing students. Some of these programs may be adaptable for deaf and hard of hearing children. Examples are: Figurative Language (Abraham, 1984); Words & Concepts II (Wilson & Fox, 1993). Rather than focusing on specific programs, the following section of the paper concentrates on general principles to consider in the design of language programs for CAI.

Steiner & Larson (1991) discuss guidelines for integrating computer technology into language intervention with children. Their focus is on what educators and speech-language

pathologists need to consider about technology in order to provide a functional program for children.

1. The focus of intervention should remain on the client. Software and hardware should allow clients to focus on the content rather than on the computer itself.

2. Computer programs should be used within an integrative model; embedding these activities in the context of the client's total language program.

3. Theoretical principles must be considered when using computer programs. For example, drill and practice with software would not be used if drill and practice is not appropriate with other materials.

4. Computer-delivered stimuli. Stimuli can generate excitement from children through colorful and animated graphics. The stimuli must be easily identifiable by children, and the graphics must move slowly enough for children to identify.

5. Computer-delivered responses must be appropriate for the child. For example, a program that activates a speech synthesizer when a correct response occurs, would not be appropriate for the child with a hearing loss.

6. Computer-delivered reinforcement. Children enjoy the experience of controlling the computer and being rewarded. However, reinforcement may be time-consuming, may always employ a 100% reinforcement schedule, or may be distracting to students.

7. Because functional communication is important to emphasize in language programs, a clinician's presence is needed so his/her observations can serve as a continual foundation for adjustment of language goals.

8. Software should be flexible enough to serve multiple goals: for example, one program might include production of appropriate answers to Wh-questions, generation of subject-verb utterances, and production of discourse to tell a story about events displayed. Thus, a program integrates selected, semantic, syntactic and pragmatic aspects of language.

Nippold,Schwarz and Lewis (1992) add to these guidelines the need to field test new software through rigorous treatment efficacy research.

Interactive computer programs for children with hearing loss.

Prinz, Pemberton & Nelson (1985) discuss the ALPHA microcomputer system which emphasizes exploratory learning, rather than programmed instruction. This approach involves

an interactive computer system that allows the child to initiate communication to a skilled teacher about a topic of interest. This is done by a combination of printed words on a keyboard and any available language mode, such as sign, speech, etc. The resulting system is one described by Prinz, et. al. as the teacher-plus-child-plus-computer system.

The ALPHA lessons contain four primary modules: individual words, creating sentences, testing words, and testing sentences It was designed to familiarize beginning readers with basic grammatical sentences. Vocabulary words are presented, using graphics, children can then create noun-verb-noun sentences using that vocabulary, for example; DOG CHASES RABBIT, or ALLIGATOR EATS COOKIE, with resulting animated graphics. Sign language representations of the words are also available. Once new vocabulary is presented and sentences are created, the teacher can switch to the testing modules and assess the child's competence (Prinz, et.al., 1985). In addition to computer mediated learning, conversations about the images on the screen can occur between the children and teachers.

The creation of a program which encourages interaction between the teacher and the child is desirable for naturalness of conversation. The children have some control over choice of semantic and syntactic forms. However, the ALPHA program itself, limits the types of sentences that can be constructed as well as the vocabulary involved. Specific suggestions for integrating other language areas are not available.

Interactive videodisc systems have been used with children with hearing loss in an extensive project at the California School for the Deaf at Riverside (Brawley & Peterson, 1983; Osksa, 1987). Student goals for this project included:

- "Improving students' skills and understanding of the language structures evaluated by the Test of Syntactical Abilities.
- Building students' vocabularies.
- Improving students' skills in sequencing events, recognizing correctness in grammar and syntax, question response, categorization, spelling, capitalization, punctuation, and sentence construction" (Osksa, 1987, p. 78).

The system involves an authoring program for teachers which provides for the creation of individual lessons in a short period of time. The lessons are menu driven, each consisting of a series of questions related to improving students' language skills. The teacher may decide

the type and number of questions to use for each individual and may use any combination of skills described above (Osksa, 1987).

The students are then exposed to the videodisc, which includes a variety of video sequences used for the language principles chosen by the teacher. The computer permits student input and monitors student understanding and progress (Brawley & Peterson, 1983).

The videodiscs describe the experiences of an old miner and his friend. They visit places and are involved in activities that one would expect to encounter in everyday life, including the use of sign language. The visual sequences incorporate teaching of concepts from the TSA. The software allows questions in each lesson, which determine the degree of difficulty, to vary. Such flexibility makes the visual sequences appropriate for a variety of age levels (Osksa, 1987).

This program teaches specific syntactical concepts known to be difficult for children with hearing loss. In addition, it provides visual input, flexibility for use with children of different ages, and choices about the specific areas of syntax to be taught. Although a stated goal of the program is building student vocabularies (semantics), it is not clear how that occurs. Teachers have choices about specific areas to be taught, but the choices are limited to the pre-programmed forms.

Network based programs are currently being used at all age and grade levels with children having hearing loss (Bruce, Peyton, & Batson, 1993). The ENFI (Electronic Networks for Interaction) approach was developed at Gallaudet University, Washington, D.C. in 1985. The purpose of this program was to give deaf students opportunities to use written English in differing ways.

The process of the network based program involves opportunities for several individuals to engage in ongoing "real-time" dialogue. Messages are composed by individuals and transmitted to all other screens involved in the network. As individuals type and send messages, the messages scroll up the screen, with the name of the sender attached, forming a script similar to that of a play. While individuals compose on a private window at the bottom of their screen, other messages from class members continue to scroll up the screen. Participants can read previous messages, as well as continue composing new ones. (Bruce, et.

al., 1993). The computer stores the entire conversation, so that it may be reviewed at any time.

The vision for the development of this program includes the following concepts:

1. New social dimensions in the classroom. This program would involve new roles for both teachers and students in the classroom. The teacher would become more of a collaborator, instead of a lecturer and student participation could be more equally distributed.

2. Writing for authentic purposes. In this context, writing would become more conversational and less formal. Students would be able to use communicative intents, such as persuading or informing in "real-life" situations; practice initiating and terminating topic areas and negotiate meaning. In addition, students could compose text and learn to move easily from one type of communication to another.

3. Immersion in a writing community. Writing would be done for a present audience, immediate feedback on ideas could be received, and more freedom and variety in writing could occur.

4. Collaboration in writing. New approaches to writing may be developed. Participating individuals may think and plan together and then write individually.

5. Writing across the curriculum. It is possible that writing in such a manner may accomplish goals in curriculum content areas such as math and history. (Bruce, et.al., 1993).

Bruce, et. al. (1993) discuss how different facilities use ENFI. They discovered the following six different "realizations" or groupings. 1). Discussion: students represented their own ideas by engaging in open discussion, cross-age tutoring, confrontation of issues, analysis of data, discussion of texts, therapeutic discourse, brainstorming and prewriting. 2). Role-playing: students did not represent themselves on the network, but adopted roles, either by choice or for an assignment. They created dramatic productions and became involved in specific role-playing scenarios. 3) Response to student writing. Teachers engaged in one-to-one dialogue with students as well as shifting from one student to another and students worked together as peer response groups, evaluating and critiquing each other. 4) Collaboration in writing text, 5) Language games such as 20 Questions, and 6) Distributing text to be used for later discussions.

The ability to create natural conversation and dialogue is emphasized in network based programs. In addition, there is potential for working with many forms of language: developing narratives; using syntax and semantics; using pragmatic abilities such as the expression of different intentions; cohesive devices; and rules for conducting discourse.

In two separate studies, the use of interactive conversational writing and writing about experiences with no correction of syntax, were shown to result in improvement in the use of syntactic skills (Harrison, Simpson & Stuart, 1991; Staton, 1985). These studies did not involve computers. Staton (1985) described the use of a dialogue journal, where the student and teacher passed a hand-written notebook back and forth. She hypothesized that functional interactive conversation can be created through writing rather than face-to-face conversations, and correct grammar can emerge through the experience. Harrison, et. al. (1991) indicated similar findings using non-corrective writing.

The value of interactive writing programs is well worth investigating using continued and careful efficacy research. The ENFI program described above is clearly applicable to older children. How network programs may be used for young children learning to write is a challenge for the future.

Recommendations.

Following are recommendations for future development of MMT for children with hearing loss. These recommendations are based on the information presented in this section of the synthesis.

1. The specific problems of children with hearing loss are not well defined in the literature, nor is there agreement on how best to encourage the development of English language in these children. This suggests a need for program developers to work closely with researchers to help determine the most important elements to be considered for program development.
2. Little longitudinal evaluation to show the efficacy of programs which purport to help the infant/young child with hearing loss develop English language are available. Such evaluations can be built into programs, thereby providing guidelines for future adjustments and development

3. Some programs viewed as "language" programs by professionals, are limited to only one aspect of language, e.g. syntax. Although it may be appropriate to work on syntax with certain children, it is desirable to clearly indicate that such a program is limited in scope and addresses only one specific aspect of language.
4. Specific or task-oriented teaching is, by itself not consistent with a current model of language development. A conversational interactive-functional approach in which children are involved in dynamic communication exchanges is encouraged. This would necessitate further development of materials which are related to everyday experiences and the process of communication.
5. Programs do not consistently identify the theoretical base on which they are developed. This suggests the need for a careful consideration of the model on which specific materials are designed and the inclusion of such information in the materials themselves.
6. Professionals working with children with hearing loss, view the availability of age and interest-appropriate materials as a problem in selection of instructional materials. This suggests:
   - A need to consider different developmental levels for materials development, and
   - A need to design instructional materials which represent experiences that are appropriate for children with hearing loss, for example, stories that tell about the lives of deaf children. In addition, cultural differences (e.g. Spanish, Black) need to be considered.
7. Professionals working with children with hearing loss note a lack of emphasis on appropriate skills. This would suggest that within specific language areas, materials need to be developed that address problematic aspects of language, e.g. figurative language, specific aspects of syntax such as pronominalization and other areas discussed in the research.
8. This synthesis emphasized the need for programs to address several specific areas of language simultaneously. Thus, a single program or set of materials would have multiple goals, e.g. in the areas of syntax, semantics and pragmatics, and would provide for interaction of multiple skills.

9. Programs in specific skill areas may involve the ability to talk about and evaluate ones own language. This ability, called metalanguage, has been shown to develop throughout the elementary school years. Thus, careful consideration of developmental levels is important when using such materials.
10. It is recommended that specific teaching approaches not make up a significant portion of the school day. When specific materials are developed, they could include suggestions for incorporation into the regular curriculum and classroom activities.
11. Some MMT do not rely on visual input as much as would be desirable. Children with hearing loss are dependent on vision to input information; thus the need for appropriate visual stimuli is crucial.
12. Programmed instruction (such as CAI) may not provide enough flexibility for individualization. Incorporating teacher participation into technical programs with suggestions for integrating such lessons into the context of the classroom would be appropriate.
13. Many technological programs have limited human interaction. The continued examination and development of network based programs provides an opportunity for social interaction at the written level.
14. Most of the technological programs are used with school-age children to refine English language skills. It is important to examine how MMT may be used in the future to help develop a strong language base for children during infancy and pre-school years.
15. Continuing research in language development will bring about a new understanding of the process of development. This suggests the need to design programs which are able to be modified and revised over time.

Limitations of this paper.

The complexity of language itself makes a thorough evaluation of "language" programs difficult. Language is involved in mental processes such as memory, problem-solving, inferencing, etc. There are probably many programs available that address these specific

areas and bear on the development and refinement of language use. In addition, there are curricula developed for reading and teaching of other content areas. These areas were not included in this research synthesis.

In addition, the use of MMT in preparing parents to assist their deaf or hard of hearing children in the development of language was not included in this review. Also, the issue of "what kind" of program (aural-oral, Cued Speech, ASL, etc.) is most likely to encourage the development of a strong language base for learning is beyond the scope of this paper.

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Media, Materials, and Technology for the Development of ASL

Elizabeth A. Winston, Ph.D.

INTRODUCTION

This section of the synthesis focuses on the media, materials, and technology related to American Sign Language (ASL) as it is used in the education of deaf children. The use of ASL in education is controversial at this time and has only recently been accepted into classrooms as a primary language of education. Because of this recent acceptance of ASL, there exist limited resources for researchers, teachers, and parents in the areas of acquisition studies, ASL teaching, effectiveness of education through ASL, as well as in the areas specifically targeted by this synthesis: media, materials, and technology.

This synthesis focuses on two areas:

1) *A review of proposed curriculum that advocate the teaching of ASL as the first language of instruction for deaf children.* Only one such proposal exists at this time, Unlocking the Curriculum: Principles for Achieving Access in Deaf Education (Johnson, Liddell, & Erting, 1989). It proposes a philosophy for deaf education that endorses the use of ASL as the first language of deaf children, and proposes that English be taught using principles of second language teaching, thereby providing access to printed academic materials in English. This review is followed by a recommendation for accepting the basic guidelines and suggestions of *Unlocking* as a starting point for further research and curriculum development in this area.

2) *A review of existing media, materials, and technologies related to the teaching of ASL.* As in the review of curriculum, there is a scarcity of such material; most consists of vocabulary lists of ASL signs. The few materials that have been specifically developed are for teaching ASL to second language learners. I review two programs that do exist in more depth: both have been developed with an understanding of language acquisition processes and have been introduced with the intention to evaluate the effectiveness of the materials as they are used

Topics not included in this review: This review is intended to discuss the use of ASL as a language in education. I have not investigated media, materials, or technologies related to English signing systems such as SEE II or Cued Speech. Both of these invented systems use manual support (either signs or cues) to aid children in speechreading and English development rather than ASL development. ASL is a language that has evolved naturally within the American deaf community as the common language of the community. It is a language completely distinct from English, having its own set of linguistic and pragmatic rules and structures. It is not, as many educators and researchers believed in the past, a broken or inadequate representation of English (See Lane, 1984, 1992), for a discussion of the gradual acceptance of ASL as a language.) There has been a proliferation of materials developed to encourage parents and teachers to use these invented systems with deaf children in the belief that such use will foster natural acquisition of English. These materials are not relevant to the development of ASL, although some introduce communication strategies for using visual communication systems. These visual strategies have been described based on research investigating the interaction of deaf mothers who sign with their deaf babies; thus these strategies would be applicable to the learning of communication strategies in ASL.

A second area that I have not included in this synthesis is the use of sign language interpreters to provide access to education for deaf and hard-of-hearing children. Although interpreters may provide visual access to media, materials, and technologies, they do not themselves fit in this category. Many deaf children are educated in public schools through an interpreter for some portion of their education. Thus, it is the interpreter who provides sign language access to such mainstreamed classrooms. This type of education has been accepted throughout the country as "inclusionary;" however, there exists no research at this time evaluating the effectiveness of this type of education. Issues that need to be addressed in this area include the level of linguistic and cognitive development required of deaf children before they can benefit from an interpreted education; the accessibility of educational activities that require visual attention to two different inputs simultaneously; the quality of interaction that students can experience in interpreted classrooms given the processing time required for interpreting; the quality of an interpreted interaction for learning in the classroom, especially in the lower grades. Given the current popularity of mainstreaming, or "inclusion," such research needs to be given an immediate priority.

BACKGROUND--HISTORY OF ASL IN EDUCATION

Early childhood deafness results in a home environment for many children in which the native language of the home is not naturally acquirable by the deaf child. Children who are not born into deaf families (these are 90% of deaf children) often experience delayed language acquisition because they cannot hear (and thus acquire) the spoken language of the home and because the parents do not know a signed language that the child could acquire naturally. In the past, the deaf child has been required to learn the spoken language of the home (through overt teaching). This emphasis on the spoken language has resulted in little use of signing in education until recently.

More recently, hearing families have also had the option of learning a signed language or system so that the deaf child can acquire a visual language or system naturally. In the 1960's, a major change in the philosophy of teaching English to deaf children occurred. Educators added signs to support the speechreading efforts of these children. Although not a new idea (it existed before 1880), US educators attempted to institute this new method of communication, called Simultaneous Communication. The system is based on the belief that a spoken language can be adequately reflected visually by matching English words with manual hand signals. Many of the hand signals were in fact borrowed from ASL and adapted to represent English rather than ASL.

Several such systems were developed throughout the US. The most widely used at this time is Signing Exact English, (S.E.E. II, Gustason 1980). These systems attempt to represent spoken English visually by combining signs from ASL with English semantics and grammar. These systems found acceptance among hearing families and educators who did not know ASL but who supported the philosophy of using manual support systems for modeling and teaching English. These sign systems were invented for the purpose of teaching English to deaf children and have proven controversial in the deaf community and in deaf education due to the invented nature of these systems, (as compared to the naturally evolved language of ASL).

The most recent approach to educating deaf children is based on the philosophy that the natural language of children who rely on visual input is a visual language. This visual language must be totally visual, with no reliance on any features that require auditory access,

i.e. the language cannot rely on sound.[1] In the US this natural first language of deaf children (the language that they can acquire normally) is commonly accepted to be ASL. This language provides complete visual access for natural acquisition by deaf children. This approach is controversial, and has been adopted by only a few schools in the US. It is commonly referred to as the Bi-Bi approach (bilingual-bicultural).

This approach has focused on natural acquisition of ASL, encouraging parents and teachers to provide rich ASL environments for deaf children, especially those who were not born into them. These bilingual-bicultural approaches to deaf education, in which ASL acquisition occurs as a natural by-product of interaction with users of the language, are becoming more popular despite the lack of clear evidence to support them. My review recommends that these programs receive much more attention from researchers and from developers of media, materials and technologies because they provide for the most natural access to education provided that deaf students are truly acquiring ASL in the environment.

My section of the synthesis focuses on media, materials, and technology for ASL in education. This brief description of the history of ASL in education is intended to clarify the reasons that so little such media, materials, and technology exists. The recent acceptance of ASL as a language of education means that little is known about its use and effectiveness for education. The underlying assumption is that, given a natural, completely accessible language such as ASL, deaf children will acquire language and progress through education normally. Little is known about the effects of such enrichment environments on children who do not enter them with some pre-existing language that can be enriched. It has been assumed that these children (primarily those from hearing families) begin to acquire ASL at whatever age they first encounter it. The programs that endorse ASL as a first language therefore do not provide specific and explicit teaching of ASL to these students. Such an assumption needs investigation.

1) Review of Proposed Curriculum for First Language Acquisition of ASL

At this time there exists only limited research on the acquisition of ASL as a native language. As these studies progress, educators will understand more about the underlying

[1]Although many deaf children have some level of residual hearing, they cannot rely completely on this hearing for natural language acquisition. The only language that is completely accessible to deaf children is a visual language

processes of ASL acquisition. In the interim, several assumptions are made in the development of educational programs intended to introduce ASL as a first language and English as a second language for deaf children. One such assumption is that deaf children with no other handicapping conditions will acquire ASL at any age. Thus, there is no emphasis on teaching ASL to deaf children, no matter what age they first are exposed to ASL. Children from hearing families, for example, are often not introduced to ASL until the age of two-five (or even much later). When they are eventually enrolled in a school system that provides them with ASL input, it is assumed that they will automatically acquire ASL. While deaf people's experience points to the general validity of this assumption, it has not been verified through any sort of investigation. Given the late exposure to ASL that many deaf children get, it must be assumed that there may be some problems in this acquisition that could be avoided or ameliorated through focused teaching of ASL structures to these children.

As investigations of ASL acquisition have been instituted, so have educational programs that incorporate ASL as the language of instruction. Although not yet guided by research results, they are guided by general education and language development principles. These have been brought together in a document entitled *Unlocking the Curriculum: Principles for Achieving Access in Deaf Education* (Johnson, Liddell, and Erting, 1989). This document proposes a model for bilingual-bicultural education for all deaf children that includes both explicit teaching of ASL and implicit acquisition through a language-rich environment. The proposed model recognizes the need for early exposure to ASL and suggests a model for providing it. Although some 'bilingual schools" have been set up around the country (and the world), the approach cannot be labeled strictly bilingual. The practical reality is that deaf children will not be able to use spoken language input for learning content in the curriculum. All live teaching can only be done through signs: either ASL or an English-based system that inadequately reflects the form and substance of the spoken language, or through a written English medium. Additionally, deaf children will not become literate in both languages, because ASL does not have a written form. If and when a written form is developed and its use becomes widespread, this problem may slowly change as materials are written and/or translated into written ASL. Thus, the form of the education is not truly bi-lingual as many people understand it -spontaneous communication will take place only through signs (ASL) and literacy is developed only in English. Based on literacy in English, students learn to

speak and speech-read, once they have something on which to base their speech and speechreading.

The model proposed by the authors of Unlocking the Curriculum is bases on the following basic tenets (pgs 15-19):

- Deaf children will learn if given access to the curriculum.
- The first language of deaf children should be a naturally accessible sign language (ASL in the US).
- The acquisition of a natural sign language should begin as early as possible in order to take advantage of critical period effects.
- The best models for natural sign language acquisition, the development of social identity, and the enhancement of self-esteem for deaf children are deaf signers who use the language proficiently.
- The natural language acquired by a deaf child provides the best access to educational content.
- Sign language and spoken language are not the same and must be kept separate both in use and in the curriculum.
- The learning of a spoken language (English) for a deaf person is a process of learning a second language through literacy (reading and writing).
- Speech should not be employed as the primary vehicle for the learning of a spoken language for deaf children.
- The development of speech-related skills must be accomplished through a program that has available a variety of approaches, each designed for a specific combination of etiology and severity of hearing loss.
- Deaf children are not seen as "defective models" of normally hearing children.
- [The authors] concur with one of the observations of the report of the Commission on Education of the Deaf, that "there is nothing wrong with being deaf" (1988:vi).
- The "Least Restrictive Environment" for deaf children is one in which they may acquire a natural sign language and through that language achieve access to a spoken language and the content of the school curriculum.

The authors of *Unlocking the Curriculum* also propose a model for designing an educational program that follows their stated philosophies. Although it is not explicit in terms of the implementation of such a program, it provides broad guidelines for developing such a program and suggests specific components of the curriculum as well as directions for further development and research. Program components would include the following (pgs. 1923):

1-Family support program

- providing support and a rich language environment for the deaf child and the
- family through support groups
- weekly deaf community contact (foster grandparents)
- family education and counseling by professionals
- weekend camp programs to provide occasional intensive contact with the deaf community
- summer camp programs to provide yearly, long-term contact with the deaf community

An essential component of their model is the Child Development Center-where children would be immersed in ASL interactions.

2-Family-Infant-Toddler program, to include programs for

-the Family:

ASL teaching

family counseling

deafness education

-infants-toddlers:

ASL acquisition

play groups with focus on language and psycho-social development

reading readiness

speech readiness

auditory stimulation

cognitive development

socio emotional development

motor skills development

3-Preschool-kindergarten

ASL acquisition

play groups with focus on language development

reading skills

speech skills

auditory stimulation

cognitive development

socio-emotional development

motor skills development

4 -Grades 1- 1 2

add English literacy skills

They recommend an administration, research and development section that would focus on the language acquisition of these children, suggesting research and development along the following lines (pg. 22):

1. Videotapes for sign language training directed toward both parents and children
2. Print materials for reading readiness, reading and writing
3. companion print and captioned video materials to accompany standard grade level content sources
4. Video materials on deaf people and their way of life
5. Print and non-print materials for teaching English as a second language
6. Print and non-print materials for teaching ASL arts
7. Exploration of interactive videodisc-computer technology for the provision of comparative ASL and English passages, as described by Hanson and Padden(1988)

Unlocking the Curriculum is the most explicit document to date regarding ASL acquisition. It does not provide a curriculum as such, but recognizes the necessity of providing an environment where deaf children can acquire ASL naturally without having to progress through a curriculum at the same time. The guidelines and recommendations for development and research as outlined in *Unlocking the Curriculum* have not yet been fully

established and evaluated in any program. The three bilingual-bicultural programs in the US (The Learning Center in Massachusetts, The Indiana School for the Deaf, and Fremont School for the Deaf) have incorporated many of the basic tenets if not the actual model. These have become officially Bi-Bi only within the last five years. It is too early to tell if these programs are proving any more successful in providing appropriate access to education through their focus on ASL as a primary language of instruction. Other schools, such as Kendall Demonstration Elementary School which is housed at Gallaudet University in Washington, DC, are not officially bilingual-bicultural programs but are currently allowing teachers to use ASL in the classroom.

For the past three years, faculty from these programs across the US have attended a series of conferences focused on bilingual-bicultural education for deaf children. The emphasis of most presentations has been the need for such education and an outlining of the possible components of such programs. These outlines are similar in most ways to *Unlocking the Curriculum;* this emphasis highlights the relative newness of the philosophy. Presenters have not yet focused on how to implement these programs in any depth. However, based on the experiences of similar programs in Sweden and on the general principles of language acquisition and educational effectiveness, the philosophies and recommendations of *Unlocking the Curriculum* offer a preliminary model that includes explicit teaching of ASL as well as a language rich environment for the natural acquisition of ASL.

Bi-Bi education for deaf children has been practiced for a longer time in Sweden. In a 1991 report on deaf education in Sweden and Denmark, Davies describes similar educational philosophies for deaf children. They begin with the assumption that deaf children will acquire a sign language normally if given the opportunity.

Both in Sweden and in *Unlocking the Curriculum*, there are two main emphases: the provision of a rich and natural signing environment that allows deaf children to acquire language naturally; and the involvement of the adults in the deaf child's family in learning signing and in interacting with deaf adults.

RECOMMENDATIONS FOR CURRICULUM AND PROGRAM DEVELOPMENT

The most important guidelines for developing media, materials, and technologies for deaf and hard-of-hearing children in terms of ASL acquisition are those that will provide them with early and frequent opportunities to acquire this visual language naturally through

interaction with native adult signers, and later with signing peers. These are the principles for promoting and encouraging normal language acquisition in any child and are the accepted norms in the field of acquisition of ASL. Although the study of ASL acquisition as a native language is relatively recent and longitudinal studies have been underway for only a few years, previous investigations of such natural acquisition indicate that deaf children exposed to normal language environments progress through predictable stages of ASL development, becoming competent language users who can go on to learn a second language such as English successfully. The goal of educational programs that encourage the introduction of ASL as a first language to all deaf children are to provide them with rich and frequent opportunities to interact with fluent signers in order to encourage language acquisition in conjunction with cognitive development. This goal is the same for all deaf children, whether they are both into such an environment or must be consciously provided with such an environment.

Development of media, materials, and technologies for ASL must be guided by research and understanding of the acquisition of ASL by children from their parents. Such acquisition begins with the early acquisition of prelinguistic features of ASL such as appropriate eye-gaze and attending behaviors, attention-getting behaviors, turn-taking behaviors, conversational pragmatics including opening, maintaining, and closing behaviors for communication; and the early understanding that gestures and movements are meant to communicate. Acquisition continues through more and more complex linguistic development until children become fluent signers. An understanding of these stages must form the basis of research and development of any media, materials, and technologies in order to be effective in the development of ASL skills in education.

Development of effective media, materials, and technologies should be based on the results of research and experiences of programs built around the philosophies of *Unlocking the Curriculum*. Research money should be directed toward investigating the specific methods used for providing a language-rich environment for deaf children, the natural stages of ASL acquisition in deaf homes (including- the prelinguistic stages of acquisition), the effective methods of encouraging hearing family-members to become involved in learning ASL as a second language, the effectiveness of such an ASL as first language/English as second language approach in the education of deaf children. Development of media, materials, and technologies without first understanding these issues will lead to the

development of many language programs that are ineffective for improving, language acquisition and therefore the education of deaf children.

One essential aspect of research in this area is classroom oriented research that values teachers and parents input, especially that from deaf parents and teachers regarding growing up deaf and learning visually. The input of native signers has usually been ignored in educational policies. Using the knowledge and experience of people who are most aware of the visual needs of deaf children will lead to curriculum and materials development that will be both theoretically sound and practically feasible in the real world of the classroom and the home.

It is also necessary to value the input from the hearing family members regarding learning how to adapt to visual life and visual communication on a daily basis. Adapting to a visual mode of communication is not simply a matter of adding- signs to conversation; it is an awareness of the visual nature of deaf children's learning. Hearing family members must learn to adapt attention-getting behaviors (parents cannot get their deaf child's attention by calling them from behind), conversational patterns (visual conversations require visual contact-they cannot occur when one person is in another room or is looking away as they can with spoken communication), and common teaching behaviors (parents must learn to face their deaf child before giving them new information and they must learn that they cannot point at an object and talk about it at the same time-a very common behavior with hearing children).

The guidelines proposed by the authors of *Unlocking the Curriculum* for the development of ASL and the education of deaf children provide a reasonable starting point for the development of media, materials, and technology for the development of ASL in deaf children.

2) REVIEW OF EXISTING MEDIA, MATERIALS, AND TECHNOLOGIES

Following the principles of language acquisition and educational development *Unlocking the Curriculum,* I have found very few materials that incorporate more than lists of signs and simple sentences. All materials had one common characteristic-they were designed for people who are already competent in one language. This language was usually English and the target population for these materials is usually hearing parents or teachers of deaf children; the materials present ASL with pictures and written English descriptions of signs and ASL

grammatical rules. Only one program that I found assumed competence in ASL in order to teach English as a second language. I found no materials, media, or technology that focused specifically on teaching ASL to deaf children. Given the assumption that ASL is acquired through interaction and exposure, I did not expect to find explicit materials for ASL acquisition. I did not find any materials that presented explicit rules of ASL structure designed for deaf children; these types of materials are found in abundance for English but do not yet exist for ASL.

In this section I first discuss in overview the variety of video and printed materials that are available for learning ASL. (Most of the available videotape series and curriculum that do exist are based on some type of English curriculum and English signing, such as SEE II, and have not been reviewed. These often have vocabulary lists of signs that are to be used in conjunction with English grammar.) I follow this with an in-depth discussion of the two programs that incorporate some of the principles from *Unlocking the Curriculum* and a clear research agenda for evaluating the effectiveness of the programs. Both types offer interesting possibilities for further development of ASL media, materials, and technology.

Given the recent introduction of ASL and the philosophies of Bi-Bi deaf education, it is understandable that the areas of media, materials, and technology are lacking in materials. The media, materials, and technology that exists have been directed toward the teaching of ASL to the hearing family members of deaf children. The goal of these materials is to help these family members communicate naturally with the deaf child and to allow them to be language models for their deaf children. The three areas of media, materials, and technologies are integrally related: most rely on some type of technology to visually reproduce the signs of ASL and are accompanied by written materials that describe or explain the signs and grammatical structures in English. (These materials are supplied in English because ASL does not have a written form.) The descriptions are accompanied by drawings or pictures of signs. All of these materials have one feature in common- they all assume a competence in one language to teach ASL as a second language. Many of these materials use video technology to demonstrate signs for students.

Examples of these videotapes are:

Fables and Fairy Tales:

Consists of five one-hour videotapes with fables and fairy tales signed in ASL with English voice-overs. It is also possible to buy a variety of written materials to complement

the collection--printed text; crossword puzzles based on word from the texts; word challenges; secret message decoding; scrambled words; drawing activities, connect the dots, coloring/tracing pages, solve the maze, teacher answer keys (Description summarized from the Sign Media Inc. catalogue)

All of these activities are based on the assumption that ASL is already in existence. these can be used to provide an enriched input and for teaching English as a second language (or vice versa-used for English speakers who are trying to learn ASL); not geared specifically for any age group although the content makes them most suitable for young children.

Parent Sign series:

This is a series of 10 videotapes that are designed for hearing parents and families of deaf children. They are aimed at helping the parents learn ASL as a second language -the format shows a series of family situations and interactions with vocabulary and grammatical structures. They are for teaching ASL as a second language-the sign vocabulary is accompanied by English glosses (Description summarized from the Sign Media Inc. catalogue).

This set of (and type of) tapes addresses the need for those parents who are hearing to have access to learning ASL. Each tape is one hour long and can be used independently by parents at home. This indirectly addresses the need to expose deaf children to signing by helping their parents sign. It could also allow the deaf children to watch signing, but would not promote acquisition since it does not provide interaction. Interaction might be achieved if parents learned and played with the child while learning. However, it cannot make the parents appropriate ASL models for their deaf children.

Rainbow's End:

This was a TV series produced in the 1970's; five tapes 30 minutes long-similar in format to Sesame Street; again, it is aimed at enriching the children's environments, building vocabulary, and language use program had the following stated goals:

- To provide persons and situations which will enhance the self image of deaf children
- To encourage activities which lead to the acquisitions of English language and reading skills
- To stimulate family interaction as well as interaction within the classroom

-- To present too hearing persons an awareness of the communication and culture of deaf persons

Each tape also comes with a workbook.

(Description summarized from the Sign Media Inc. catalogue)

This program is aimed at building English through visual enhancement and through ASL, but it also provides sign instruction and a motivating way of showing signs to children and of exposing them to sign language.

Bravo Family Series:

This is a series of videotaped scenarios at a slightly more advanced level that introduces ASL in context. These are geared for an older group and are intended for use with English speakers who are learning ASL as a second language.

Many of the materials advertised as teaching sign language are not explicit about whether they are English signs or ASL; others promote confusion by advertising that they teach ASL signs in English word order. Since ASL does not have the same set of signs that English has, this is not possible--ASL does not use the same determiners that English uses, for example; therefore materials cannot match ASL signs to English sentences.

Many tapes and games promote the learning of the manual alphabet only and do not include any sort of grammatical instruction at all.

Books advertised had same disadvantages as the videotapes: many are vocabulary lists-some are English signs and some are ASL signs. Although some curricula exist for teaching ASL as a second language, all are aimed at adult learners and are not suitable for children in the age group of this synthesis.

Overall, the video materials and books do not provide any focused attempts to present ASL as a language system for children in this age group. They are generally vocabulary and sometimes sentence based. A few place signs in a larger context of story telling-these are often accompanied by written texts and are designed for teaching English as a second language to people who already know English (or perhaps could be used vice versa).

Most consist of lists of vocabulary aimed at the needs of parents with young children. These are inadequate to teach competence in ASL for hearing parents. There are, however,

two different video projects that provide more than simple lists of vocabulary- one is an interactive videodisc program and one is a videotape series.

Interactive Videodisc Technology

The interactive videodisc program was originally developed by Hanson and Padden (1990). It was developed as a tool for teaching English as a second language to deaf children who are already competent in ASL; it is intended to teach reading and writing of English as a second language to students in grades 3-6. It was developed in collaboration with IBM. After the initial study of this program IBM has not actively pursued its development or expansion. It is not available for use although it is a promising technology for ASL teaching.

This is an interactive videodisc program that uses ASL stories to teach reading and/or writing in English. (In fact, the authors also report great interest from adult participants (teachers) in using this technology for the opposite purpose: teaching ASL as a second language to English speakers). Using the program, students can choose to try to read an English story, answering questions about the stories using written English to test their understanding at the end. They may ask for translations of any section of the story in ASL in order to enhance their comprehension at any time. Both the stories and the questions are provided in both written English and in ASL, allowing the students to use either the ASL version or the English version or both.

Children can work individually or in pairs; the researchers found that pair work stimulated interaction about the stories and about the processes involved in moving from ASL to English. The children were very enthusiastic about the process. Thus, it was not only the program itself that helped to develop language (in this case English), but the interaction between the children helped to develop language competence in ASL and allowed them to use ASL to learn about English.

Although this specific research project was aimed at teaching English to deaf children already competent in ASL, it reveals the value of this type of program for maintaining the interest of deaf children in a language lesson. This type of program could be adapted in various ways to teach either ASL or English. This technology also has potential for parent-child ASL acquisition: hearing parents who are trying to learn ASL as a second language in order to use it with their deaf children could watch these discs with their children; it might

provide interactive stimuli for them to use with their children. Perhaps also deaf adults could use this type of program with both the parents and the children, modeling interaction in ASL.

The advantages of this type of program are that it can provide an interactive learning environment that is interesting to children--this encourages language learning and could entice parents and teachers to improve their ASL with children in a non-threatening environment.

If it were available at schools, parents could have access not only to the program, but might be more enthusiastic about participating in the child's education in general.

The major disadvantage of this type of program is that it requires access to computer equipment and programs that many parents may not have at home-the technology itself is expensive and may be intimidating. A second disadvantage is that developing the videodiscs is expensive and time consuming. However, as computer aid video technology progress, both of these disadvantages may become less problematic. CD ROM technology also offers the prospect of such interactive programs for families and for deaf children learning ASL[2].

Sign With Me - videotape series

This series of videotapes, Sign With Me: A Family Sign Program, developed by Mary Pat Moeller, Brenda Schick, and Kevin Williams from Boys Town National Research Hospital in Omaha, NE, is designed for the development of ASL skills in caregivers of young deaf children. The curriculum is designed to integrate signing skills, linguistic development, pragmatic communication skills, and parenting skills.

The developers have designed a series of three units intended for parents of infants and toddlers; pre-school age, elementary school. Each unit will include 2 videotapes that focus on vocabulary, functional phrases, facial expressions, pacing and phrasing. The goals of the designers of these series go well beyond the goals of most video series: in addition to adding to the vocabulary of caregivers, they want the caregivers to develop conversational fluency both in signing to children and in understanding children; they will develop fluency in communicating with a variety of native signers, their signing fluency will be beyond that of

[2]In the year since this review was submitted, the technology of video conferencing has become more viable. Video-conferencing could provide more interactive type settings for deaf children and parents with deaf role models of ASL and signed interaction.

the children, and they will learn about parenting techniques relevant to visual communication and language development.

To date, it is the most sophisticated ASL video series in terms of incorporating what is known of linguistic, pragmatic, and learning principles in ASL. At this time only the first unit is available for purchase. The second is in production.[3] The designers have begun some follow-up research into the use of these tapes and have so far collected responses from families who have begun using the tapes and accompanying workbooks. Parents appreciate the exposure to both the signs and the parenting models provided on the tapes, and feel supported in their learning by the tapes. They have also remarked about the ease of using these in their homes at their own pace.

The major advantages of this type of material for learning ASL are those mentioned by the parents. Because it is designed for videotape, the technology is accessible to most parents. They attempt to provide language models rather than vocabulary lists, recognizing the importance of all aspects of communication. The intention of the designers at this time is to make the series available through video outlets and public libraries-achieving wide dissemination at nominal prices. The designers also emphasize the need for caregivers to understand children's signing, an area that is neglected in most ASL teaching materials.

The major disadvantage of this type of material is that it does not require interaction with live language models; although the designers encourage parents to use these in conjunction with classes and interaction, the very independence that they allow can be detrimental to successful language learning if substituted for real interaction. It also has the explicitly stated goal of providing hearing caregivers with ASL competency that allows them to be ASL models for deaf children. While they may be able to achieve some measure of communicative fluency through these tapes, it is doubtful that any second language learner could provide an adequate language model for a child. It is especially doubtful that second language learners who are learning only the vocabulary and structures included on the tapes and who are learning them at the same rate that the deaf child progress through the stages can provide adequate linguistic input for acquisition

RECOMMENDATIONS.

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[3]Since the original submission of this review, the second unit has been produced and the third in production

Media, materials, and technologies should be developed based on findings of programs that encourage the development of ASL as a first language. Materials that appear to be the most promising to date are those with interactive video learning and videotape series that approach ASL development with the perspective of developing all aspects of the language, not simply a list of vocabulary. Materials that have been found to be especially effective to date include sign language courses that incorporate videotapes and interactive videodiscs. The most important characteristic of language acquisition is interaction with users of that language; thus, any materials that encourage such interaction, either between adult language models and deaf children or between deaf children themselves are predicted to be the most effective for developing ASL and therefore for providing access to education for deaf children.

Materials and technology that encourage family members to interact with adult language models are also needed. The development of videotapes and interactive computer programs that families can use at home will be useful as long as they focus on language learning and not simply on lists of vocabulary. They will also only be useful if they provide communicative information to hearing family members: information about how to get a deaf child's attention, how to interact visually, and how to recognize stages of ASL acquisition in their deaf children. The use of interactive video-conferencing technologies may make it possible for deaf children to acquire ASL from native signers more effectively as well. This type of technology-aided communication should be investigated for both language acquisition and education for deaf children.

Another direction for materials development is that of training native signers as teachers of ASL. Trained native signers provide an informed language model for both deaf children and their hearing families. At this time, only one such program exists in the US. It is a master's degree program and is currently housed at Western Maryland College. Again, these teachers and role models could be made more accessible to deaf children and their families through interactive video-conferencing.

CONCLUSION

The clearest finding of this section of the synthesis is the lack of curriculum, media, materials, and technology available for developing ASL in the target group. This finding underscores one of the main reasons that bilingual-bicultural programs have met with

resistance from so many educators -the lack of a defined curriculum for developing ASL, in addition to a lack of curriculum that would help these educators become fluent in ASL in order to work in ASL programs. These gaps lead to the recommendations in this section.

Recommendation #1 is to develop a curriculum based on the needs of children in acquiring a visual language. Development of this curriculum should take full advantage of the knowledge and experience of those involved in Bi-Bi programs, especially native signers and experienced teachers. This curriculum would provide for a consistently rich ASL environment for deaf children that includes both ASL enrichment goals and explicit teaching of ASL structure, including both linguistic and pragmatic aspects of ASL communication. Such a curriculum needs to be developed based on research into the stages of ASL acquisition in deaf children from families that use ASL as their home language.

Recommendation #2 is to develop media, materials, and technologies such as the Interactive Videodisc program, the Sign With Me: A Family Sign Program, and interactive video-conferencing that can actively direct and enhance the language acquisition that should be occurring within the ASL environment provided by the curriculum. There are two target populations for these media, materials, and technologies: deaf children, especially those from hearing families that cannot provide natural access to ASL because it is not their own native language; and families and teachers of these children, who need to be able to communicate effectively with them and who need to be able to recognize the progress of ASL acquisition in the children This review has shown that the Interactive videodisc program arouses enthusiasm from both students and teachers; the Sign With Me program has generated enthusiasm from hearing families with deaf children. Such interest in learning ASL is an important first step in the development of ASL skills in deaf children. The further development of such teaching materials and of curriculum that guides such materials needs to be based on research investigating the effectiveness of the curriculum and materials in providing access to education for deaf children. This research is a vital first step in the future development of any and all media, materials, and technology

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1987-1993 Educational Technology

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1986-1993 Computer and Education Journal

1986-1993 The Computer Resource Quarterly for People with Disabilities

Computer Searches on:

ALAD: Washington Research Library Consortium

DWIL: Periodical Indexes (multi-subject)

PAPR: Newspaper Abstracts

ERIC: Educational Resources Information Center

Topics searched:

Hearing Impaired and Language Programs

Deaf and Language Programs

Hearing Impaired and C.A.I. and Language

Hearing Impaired and Language and Software

Deaf and Language and Software

Hearing Impaired and Language and Programs

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Hearing Impaired/Deaf and ASL and CAI

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Sign Media Inc.

Gallaudet University Bookstore

Sign Enhancers

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Oregon Literature Synthesis: Speech teaching

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Overview of synthesis

The aim of this synthesis is to examine existing media, materials and technology (MM&T) for improving the speech production skills of children who are deaf or hard-of-hearing. The synthesis is organized into three sections. Section 1 describes a series of background issues such as the sources of the synthesis, description of settings, etc. Section 2 explores the pedagogical framework in which speech teaching occurs, along with an examination of how well current MM&T facilitates speech teaching within this framework. Section 3 examines the efficacy of existing MM&T through a review of the limited literature on clinical effectiveness of speech teaching technologies. Section 4 summarizes the synthesis and provides suggestions and guidelines for development of future MM&T.

1. Limitations, sources and background

1. Limitations of current search

There is a long history of instruction designed to teach deaf children to speak, with the earliest report of speech teaching strategies dating back to the 17th century (Plann, 1993). To make the present research synthesis manageable, it is limited primarily to MM&T reported in the last 25 years (between 1970 and the present). This time frame is reasonable for two reasons. First, the majority of instructional media, material and technology available today originated in this targeted period. For example, the single most popular speech teaching curriculum in use today is that developed by Daniel Ling as described in his book Speech and the Hearing-Impaired Child (1976). Secondly, current technologies for improving the speech of deaf and hard-of-hearing children are almost exclusively computer-based. The first reported computer-based strategy was initiated in the early to mid 1970's with the exploratory work of Nickerson, Kalikow & Stevens (1976)and others. Thus the majority of current thinking and development of speech teaching technology will also be found in the limited time period of the present review.

2. Sources of current search

There was no single source of information that proved adequate for the present synthesis. Accordingly, the synthesis is based on a variety of sources, including the author's 15 years of research and development experience in this area, computer-based searches of existing data-bases, and manual searches of journals that have traditionally published articles in this areas. The manual searches were conducted on a series of journals that traditionally publish articles in the area of speech development of deaf and hard-of-hearing children, sensory devices, and computer-based speech training. These publications are listed in Appendix A.

3. Background

The following section will describe the process of speech learning for hearing children, and will examine ways in which that process may differ for a deaf or hard-of-hearing child. Also discussed are differences in speech teaching strategies that are found in different educational settings.

1. Normal-hearing children and speech development.

From their earliest experiences with the auditory world, children begin to organize their mental impressions of what they hear in ways that ultimately contribute to future development of both auditory and speech skills. While our understanding of the relation between what is heard and what is produced is incomplete, the following series of steps are the likely sequence involved in acquiring speech skills.

1. As the child hears speech, an auditory pattern is stored in memory. These auditory patterns serve as both the directors of motor productions, and as the reference of correctness (Schmidt, 1988) for learning the motor patterns[1].
2. The child attempts to produce speech that he/she hears
3. Awareness of the speech patterns produced is not concurrent with production, but rather occurs after the production. The child obtains information about the outcome of the production attempt through auditory feedback and then compares the auditory pattern associated with her imitations to the stored reference

patterns. This comparison acts as an error detection mechanism whereby the production accuracy is assessed.

4. Subsequent attempts are adapted to reduce the "error" in the production, and comparisons again made.
5. Through repeated attempts to produce the pattern, the child establishes the sensory-motor transforms required to produce that pattern.
6. The outcome is development of learned transformations between the auditory patterns and the motor patterns (sensory-motor association) (Risberg, 1968).

Speech acquisition thus relies on, and is mediated by, hearing. Among the particular motor tasks involved in speaking that the child must learn through audition are:

1. Placement of articulators
2. Control of the breathstream
3. Coordination of articulators
4. Coordination of articulatory, phonatory and respiratory elements of speaking
5. Production of adequate phonation (pitch and quality)
6. Accurate articulatory patterns of the larynx responsible for the production of voice vs. voiceless contrast, together with appropriate coordination of the patterns.
7. Breath support

While the development of these skills is not actively taught to hearing children, they are substantially mastered by five years of age.

2. Speech development and the deaf child

Traditional approaches to facilitating development of speech in deaf children typically attempt to mimic hearing children's speech acquisition, albeit with a little help through amplification and instruction. Where a child has the ability to extract usable information from what is heard, this approach can be beneficial. These deaf or hard-of hearing children, through amplified audition, receive early auditory input of spoken language in the environment, and speech feedback from their own productions.

Amplification can provide some children with the primary sensory supplement needed to facilitate "natural" development of speech. For many (or perhaps most) deaf children, reliance on residual hearing alone will not result in development of adequate speech skills. With minimal or no access to the auditory signal, the deaf child is

confronted with a motor learning task without benefit of either clear targets or adequate feedback. Despite repeated exposure to speech, these deaf children do not develop speech on their own, and intensive teaching and instruction is typically indicated.

For these children with limited auditory capabilities, speech development is further confounded because the child will not have access to the environmental language. The interaction between speech and language development (or lack thereof) will thus result in further deficits in development of speech skills that can be used communicatively.

3. Teaching speech to deaf children.

As a result of these difficulties, speech is not typically acquired by this group of deaf children without some additional effort. For some, alternate approaches to developing speech skills are considered. This has involved providing the child either with alternative auditory input in the form of a cochlear implant (Osberger, 1993), or a supplemental or alternative input in the form of vibrotactile input (Vergara, Miskiel, Oller, Eilers & Balkany, 1993). For these children the goal is to facilitate natural speech production and sensory development via a prosthetic device, one that is worn all the time. The use of these approaches are discussed elsewhere in this synthesis.

Development of speech for the vast majority of deaf children in programs in the United States, Sweden, and elsewhere, requires speech instruction; these children are typically not expected to develop speech on their own (or with minimal specific intervention directed toward speech improvement), but rather they are provided specific (and for some intensive) speech teaching. Increasingly, sensory aids, both visual and tactual, are being used in speech therapy to either supplement amplified audition, or in some cases, to replace it. The speech-learning process for a deaf child who does not benefit greatly from amplification, and who must learn speech skills through visually or tactually mediated approaches, differs significantly from the speech-learning process observed in a hearing child or a deaf child whose speech development can be facilitated through the prosthetic use of amplification, or other auditory aids (Risberg, 1968).

4. Educational settings and the role of speech teaching in the educational curriculum

The amount and nature of speech instruction received by a deaf child will depend to a great extent on the type of educational setting in which a deaf or hard-of hearing child is placed. Mentioned in the introduction to these syntheses are a variety of settings, all of which differ from one another regarding the role of, and value placed on, speech.

While often not stated explicitly, these programs differ in their view of the importance, attainability, and eventual function of speech skills acquired by deaf children. In an oral program, speech is intended to be the primary means of face-to-face communication, and so the goal is to facilitate a broad-range of speech production skills. To achieve this level of speech proficiency, considerable time and effort must be directed toward speech teaching[2]. Most often, the instructional model employed in oral programs is analytical, involving stepwise "building" of speech skills. Such intervention typically involves use of amplification, and auditory training, lipreading training, and specific instruction aimed at developing speech from the bottom up.

In total communication (TC) programs, the amount of time and effort directed toward speech is generally less than in oral programs. Such reduced emphasis is somewhat understandable since it is assumed that speech and some form of manual communication will complement each other and the result will be "maximum" communication. More recently, Bilingual/Bicultural educational programs have been reported whose focus is development of English Language skills through reading and writing, In these programs speech development is considered a skill separate from language development, and not necessarily appropriate for every deaf or hard-of-hearing child.

In TC and Bilingual programs, the goals of speech instruction are likely to vary from program to program. Speech teaching in some TC programs is often aimed at development of speech that can be used for face to face communication, in much the way that hearing people communicate. Other programs aim at facilitating development of "functional" speech. Definitions of functional speech are somewhat elusive, but the term is most often used to describe speech that can meet basic needs for communicating with the hearing world where sign language cannot be relied upon. Teaching strategies directed at developing functional speech often focus on expression of language concepts as a primary goal. Thus speech drill is very much based on vocabulary and phrases deemed important for the individual to communicate in the real world. Considerably less effort is typically directed toward the more analytical or bottom-up teaching that is used to develop more broad range speech skills

To summarize, the development of speech skills, while mediated by the ability to hear in normal hearing children, is most often taught to deaf children The aims and

attributes of speech instruction often varies for different educational settings, or for different children in a single setting.[3]

2. Evaluation of MM&T in the framework of speech teaching

1. Introduction

Teaching speech skills to deaf and hard-of-hearing children typically requires consideration of at least three major factors. Among the significant factors to be considered here are: the tasks and target skill to be taught; the cues presented to the child to elicit the production; and the feedback provided to the child about his/her production attempt. The following discussion will first describe each of these clinical factors and then examine ways that existing MM&T facilitates and expands current speech teaching practice.

2. Skill Areas and Tasks

1. Clinical practice

To establish the precise speech areas to be taught to a young deaf child, the teacher typically evaluates the child to determine skills that are present or lacking. Diagnostic information is collected to determine whether or not segmental, and suprasegmental production patterns are present that might be expected given the child's previously acquired speech capabilities, age, auditory skills, and other factors impacting on speech development. In the U.S. and Canada, many clinicians rely on the teaching sequence described by Ling (1976) to determine the production skills that should be taught, and in what order. While the sequence described by Ling is arguably based on the patterns observed in normal-hearing children's speech development, this framework does provide both a useful model for selecting speech skills to be taught, and useful tools for evaluating deaf children's speech.

Once skill areas are selected, speech teaching is initiated. While the specific structure of teaching speech to deaf children may vary somewhat from clinician to clinician, there are generally four identifiable steps involved: elicit, automate, generalize, and facilitate linguistic use (Ling, 1976; Risberg, 1968).

An initial step for all speech skill teaching involves *eliciting* production of a target. For example, teaching production of the nasal consonant /m/ involves demonstrating to the child the target sound (through audition, taction or vision) and then having the child attempt the utterance until it is produced acceptably. This can often be a time

intensive task for the child, and requires that the teacher have a good understanding of the respiratory, phonatory and articulatory bases of the speech unit being taught.

Following an acceptable production, the pattern is drilled and practiced so that it is achieved without the speaker having to attend to details of the production. This is referred to as *automaticity* (Ling, 1976; Schmidt, 1988) and is considered necessary for speech to be produced smoothly and effortlessly.

Once the target can be produced easily and automatically, then the child is taught to *generalize* the production pattern to different contexts and syllable locations. Such generalization training is an important component of teaching the child to use a developing skill for communication.

Finally, the child is taught to produce the target pattern in meaningful words, or phrases. *Facilitating linguistic use* involves the transfer of skills from imitated and practiced utterances to communicative speech. Activities directed at promoting linguistic use typically start with easier tasks (such as monosyllabic words in limited contexts) and become less structured and rehearsed as the child demonstrates mastery. The desired end-point of this teaching step is the spontaneous use of the skill in conversational speech.

Each of these four major steps can be further subdivided into smaller steps or subskills that are achievable for the child. For example, generalization of the nasal consonant /m/ production might initially involve production in isolation, followed by production of the consonant after the neutral vowel /ə/. Subsequent attempts might vary vowel and syllable context. Similarly, promoting linguistic use might initially involve production of the target segment in words, followed by practice in phrases, sentences and finally conversational speech. There are thus numerous "small" steps involved as sub-components of these four major steps.

2. Description and critique of Media and Materials and Technology

Texts. Few texts have been published in the past 25 years on teaching speech to deaf children. While discussions of speech teaching in the early 70's included reference to Auditory-global, Acoupedic, and other methods of speech instruction (Calvert and Silverman, 1975), the single approach to speech teaching that is most often described today is that developed by Ling (1976). The Ling procedure (described in Speech and the Hearing-Impaired Child: Theory and Practice) continues to be the standard for teaching

speech to deaf children. Ling has also published a series of texts (through the A.G. Bell Association for the Deaf) that provide supportive materials, charts, and forms to accompany the text.

The Ling book offers a comprehensive and detailed description of the author's perspective on teaching speech to deaf and hard-of-hearing children. Presented is a rationale in support of the theory presented, including a literature review that was quite comprehensive at the time the text was developed.

The Ling approach is analytical or bottom-up. Provided is a detailed description of the sequence in which speech skills should be taught. Skills range from basic control of voicing pitch and loudness and duration, and progress through production of vowels, consonants and consonant blends. For each skill area, the child is taught to produce speech initially by imitating non-meaningful syllables. Once the child demonstrates facility with production of a pattern at the non-meaningful level, then the child is taught to use that pattern in meaningful words and phrases.

The text has provided clinicians with a well documented and detailed clinical approach to teaching speech to deaf children. There are, however, certain assumptions about the appropriate sequence of teaching speech that have been questioned by clinicians. Focusing initial attention on often difficult to achieve voice parameters, requiring mastery of five vowels before beginning work on consonants, requiring extensive ability to produce imitative patterns before introducing semantically connected speech are among the assumptions most often questioned by clinicians. As a result, clinicians often modify these "steps" in implementing Ling's procedures, resulting in what is commonly referred to as a "modified Ling approach".

There is clearly a lack of research examining the efficacy of Ling's speech teaching sequence. The teaching method has only been minimally evaluated to establish its validity as a training model. Osberger, Johnstone, Swars & Levitt (1978) examined the rate of speech skill learning by 20 children in an oral educational program when the Ling program was introduced to teach certain early speech skills. Their findings suggested that even for the children in this oral program, there were differences in learning rates that led the investigators to conclude that "...nearly one third of the children failed to make satisfactory progress". While the degree of hearing loss of these children was a likely factor

contributing to the minimal progress of these children, hearing levels could not fully explain all of the reduced progress of these children.

An additional limitation of the procedure is the implicit assumption that it will be implemented in an oral educational environment. Historically, the book appeared while total communication was in its infancy. It was reasonable that the assumed setting would be an oral program, in which considerable time and effort would be directed toward teaching speech. Now, nearly 20 years later, the educational options available to deaf children are quite different than they were when the procedures developed by Ling were first introduced. While most teachers in TC settings purport to use a "variation" of the Ling procedure, there is a dearth of direction available to the clinician about how to promote speech skills when the goals and available time for teaching speech are more restricted than would be the case in an oral program. Suggestions for adaptation of this approach to different environments are clearly needed.

It is also likely that the Ling procedure is not appropriate or desirable for all children in all environments. While strategies for achieving functional speech through top-down teaching strategies have been used in a number of educational settings, these procedures have not been well described. There is a significant need for documentation (and evaluation) of these approaches, together with development of media and materials for teaching speech to deaf and hard-of-hearing children employing these top-down strategies.

Video and other materials. A critical element of the Ling procedures is the evaluation of speech abilities at both the phonetic and phonological level. Toward that goal, a series of video tapes have been developed in which Ling demonstrates assessment procedures, and offers commentary about the rationale for various judgments and strategies for improving speech patterns.

While somewhat dated in appearance, these tapes provide useful insight into the implementation of the Ling evaluation and therapy procedures. Printed material in support of these videos would, however, be helpful.

The A.G.Bell Association for the Deaf also markets forms, workbooks, and other materials to assist the teacher in both evaluation of the child's speech skills, and recording progress made by the child in various skill areas. The materials are closely tied to the Ling Model, and provide a systematic means of keeping records and plotting progress.

Description of Existing Speech-Teaching Technology. Many computer-based devices have been designed to facilitate production of suprasegmental patterns. Existing devices also permit some work on consonant and vowel articulation, usually in limited contexts (for example, the IBM SpeechViewer™). Still other devices are designed to facilitate drill and practice of whole words. There are no devices currently available that permit extensive work on both suprasegmentals and segmentals.

Not all devices are equally suited to facilitating productions at the four steps described above. For example, the Indiana Speech Training and Evaluation Aid (ISTRA) (Watson, Reed, Kewley-Port & Maki, 1989) is designed to promote drill and practice of syllables and words by providing feedback based on a speaker dependent speech recognizer's comparison of a child's speech attempt to a stored template. The template is based on acceptable production attempts that have been facilitated by the teacher. The system is thus designed to promote automaticity, generalization, and early stages of promoting linguistic use. ISTRA contains only limited functions directed at eliciting productions, and the system was not designed to provide feedback during connected speech[4]. Conversely, the electropalatograph (EPG) provides direct feedback of contact between the tongue and palate. While useful for eliciting initial productions and automaticity, it appears less optimal for promoting generalization or linguistic use. Other devices, such as the IBM SpeechViewer II™, focus on suprasegmentals; while offering some activities that permit basic work on vowels (and to a lesser extent consonants).

3. Cues or Targets

1. Clinical Practice

The cue or target comprises the information that is provided to the child to signal the production goal to be achieved. The strength and specificity of cues provided to the child interact with the task (Mower, 1977). Cues will be very specific during earlier tasks associated with a particular skill area. As the learner obtains greater proficiency with the task, cue strength is reduced. The task level will subsequently be made more demanding, and cues will again be made stronger. Cues and tasks are thus related, and are adapted by clinicians to match the performance level of the learner.

2 Description and critique of Technology

For speech training devices, the cues provided are typically in the form of models or templates, with or without explanations provided by the teacher. Currently available

devices permit only limited adaptation of cues to the performance level of the child. However, an experimental system developed at John's Hopkins University (Ferguson, Bernstein & Goldstein, 1988; Mahshie, Vari-Alquist,Waddy-Smith & Bernstein, 1988) explored graded cuing for teaching loudness control. During earlier training steps, the intended intensity target was cued by a vertically oriented bar. The bar was divided into blocks of three different colors, each representing a different intended intensity level. Blue, at the bottom, signalled low-intensity speech, green, in the middle, corresponded to conversational levels; red, at the top, corresponded to loud speech. During later tasks, a clown holding different colored balloons was used to signal different intensity targets to be produced. The spatial orientation was eliminated, so that only colors were used to signal a desired intensity level. When the balloon having a particular color started flashing, the student was required to produce a vocalization whose intensity corresponded to the target color. While the Hopkins system demonstrated the feasibility of graded cuing in a computer based training device, no currently available commercial device provides the user with the ability to alter the level of cuing provided.

4. Feedback

Clinicians must also consider a third factor, feedback, during teaching of a particular speech pattern. Like the cues provided to the child, the feedback will vary depending on the demonstrated level of skill acquisition. Ultimately, the goal of all intervention will be for the child to self-monitor his/her productions, so that he/she is able to detect better and poorer productions without external mediation. However, such internal feedback develops only after considerable drill and practice of a particular skill. Consequently, the child will depend on external feedback to develop this more useful internal feedback.

There are a number of factors the teacher considers (either explicitly or implicitly) in providing feedback to the speech learner. Each of these factors are briefly described below, along with a brief examination of how the factor is implemented in existing speech teaching technologies. The form of the synthesis structure implemented below differs somewhat from that of previous sections. The discussion of the current clinical practice and the state of technology re. each feedback factor are presented together

The description of current clinical practice is give in regular type, while the description and critical review of existing technology is presented in ***bold italic*** type.

1. Sources of feedback information.

In traditional speech teaching, the teacher will listen to the child's attempt and provide feedback about the accuracy of the production. This feedback is most often verbal (or signed) and is based on what is heard. As suggested earlier, however, teachers have long relied on tactile or visual information as an additional source of feedback. For example, children are often taught a nasal/oral sound contrast by touching the nose and feeling the presence or absence of vibration.

Feedback provided by sensory aids can be obtained from a number of different transducers, including microphones (for example, Watson & Kewley-Port, 1990) aerodynamic measuring devices such as the pneumotachograph (Mahshie & Yadav, 1990), accelerometers (Stevens, Kalikow, & Willemain, 1975), and specialized devices such as the electropalatograph (EPG) that monitor the extent and pattern of contact between the tongue and palate (Fletcher & Hasegawa, 1983). While the majority of computer-based systems use a single transducer (for example, IBM SpeechViewer II™, there are some devices that employ multiple transducers. For example, a system developed by Matshushita in Japan, uses a microphone, accelerometer, an airflow measuring sensor, and an electropalatograph. Another device, the Nasometer™ employs a special arrangement of microphones that permits separate monitoring of acoustic energy from the oral and nasal tracts. Comparison of these signals provides an objective measure of the degree of oral and nasal coupling during speech.

2. Feedback timing.

The clinician typically manipulates both the timing and nature of external feedback to match the level of performance demonstrated by the child. The timing of feedback can be concurrent with, or immediately following the production attempt (immediate feedback), or it can be given somewhat after the production attempt (delayed feedback). Feedback can also be given after each attempt (separated feedback), or after a group of attempts (accumulated feedback) (Schmidt, 1988). Operant-conditioning literature (for example, Mowrer, 1977) suggests that during earlier stages of teaching a new skill, continuous feedback is normally provided. Maximum learning will

subsequently occur when feedback is provided on an irregular basis. As the child begins to acquire a skill, the schedule of reinforcement should be varied so that learners have an opportunity to internalize the means of evaluating their production patterns. It has been suggested that this process can be enhanced when external feedback is given less frequently and on an irregular schedule.

Few currently available devices permit manipulation of feedback timing.[5] An exception is the experimental system developed at Johns Hopkins (Ferguson, et al., 1988; Mahshie, et al., 1988), which systematically altered the timing of feedback for a series of lessons designed to teach deaf children to control vocal intensity. During early activities feedback was immediate - occurring during the production attempt. For later activities, feedback was delayed, occurring after the production attempt was completed. Only one commercially available system, the Indiana Speech Training Aid (ISTRA), is reported to provide the teacher with the ability to vary feedback schedule depending on the student's performance level (Kewley-Port & Watson, 1991).

3. Knowledge of results vs. knowledge of performance.

The nature of feedback can also vary. In some cases, it is desirable to provide the learner with information about the outcome of the attempt. Feedback provided to the learner about how closely his/her production product (speech) matched the training target is termed *knowledge of results* (Schmidt, 1988). This type of feedback can convey information about the magnitude of accuracy (right vs. wrong, 80% correct, etc.) and about the direction of the attempt (undershoot, over-occluded, etc.)

In contrast to knowledge of results, *knowledge of performance* is feedback about the actual movement patterns that were used by the individual. Providing the child with knowledge of performance involves conveying information about how closely his/her actual articulatory pattern matched the desired goal, or information about the time course of a particular articulatory pattern. Devices such as the EPG (Fletcher & Hasegawa, 1983) or systems relying on the airflow transducers (Mahshie & Yadav, 1990) provide knowledge of performance.

The majority of currently available devices present knowledge of results as the primary form of feedback. For example, the Video Voice™, an acoustically based training device, presents patterns corresponding to a Formant 2 vs. Formant 1 (F2-

F1) plot of the target word. The template and an attempt are shown on the same screen, with the extent of "overlap" (and a numerical score corresponding to the degree of overlap) providing the learner with knowledge of results of the production attempt.

There is little empirical data available about the relative importance of these two forms of feedback for speech learning. For the acquisition of other motor behaviors, knowledge of performance is extremely useful feedback when a skill is being elicited (Schmidt, 1988). It's been suggested that speech learning can be enhanced by presenting physiologic feedback that provides an explicit view of how the speech mechanisms move for production of a target segment (Bernstein, 1988; Mahshie, et al., 1984). This type of feedback would seem particularly useful for early stages of skill development, such as during the elicitation stage. During later stages, providing knowledge of results feedback would appear most beneficial, since such feedback would likely lead to less dependence on the visual display, and together with varied feedback schedules, would facilitate internalization of the task.

The majority of existing systems offer little flexibility in the type of feedback that can be provided. Generally, devices that provide feedback from physiological sensors (such as the EPG) provide knowledge of performance, while the majority of acoustically-based devices provide knowledge of results.

It is possible to obtain knowledge of performance (that is articulatory information) from the acoustic signal. For example, a number of computer-based devices offer programs that display speech spectrograms, spectral displays, or F2 vs. F1 formant displays (such as the SpeechViewer II™ and the Video Voice™) . However, obtaining knowledge of performance form such displays is not always a simple task (Bernstein, 1988) and often requires that the teacher be able to provide an articulatory interpretation to the displayed acoustic pattern.

1. Standards.

Whether knowledge of results or performance is provided to the learner, feedback requires a comparison of the production attempt to a reference. In traditional therapy, the standard against which the production attempt is compared resides in the teacher who listens to and evaluates the student's utterance. *Watson and Kewley-Port (1989) suggest that the reference for a sensory aid (particularly a computer-based device)*

can be productions by a teacher, a reference group, or the learner. In addition, the comparison can be accomplished automatically (by the system) or by judgements of the visual display made by the teacher or student.

The reference. Finding an appropriate reference is not always a straight-forward task. When the standard for comparison is produced by the learner, then it is necessary that an acceptable production obtained and stored so that it can be compared to subsequent production attempts. While this is reasonable for some task levels (such as automaticity) it is less likely when elicitation is the goal. Although possible to manually develop a model by "correcting" a pattern associated with an approximation produced by a student, few systems currently available permit such editing of targets. The one exception to this is a commercially available EPG (the Palatometer™) that enables the instructor to modify a target screen to include or eliminate specific target points. This "synthesized" target can then be used as the comparison for subsequent attempts.

Sometimes the standard used is a teacher's production (for example, the Video Voice™), or is derived from productions of the target utterance by a number of speakers (for example, SpeechViewer II™). Use of productions by other speakers can be problematic, however, since there is considerable variability in articulatory and acoustic patterns between speakers. Moreover, motor equivalence and coarticulatory effects introduce considerable articulatory variability, making invariant "templates" somewhat inaccurate for any particular production.

Nonetheless, the use of templates derived from speakers other than the learner as a standard and model appears to be beneficial for teaching skills to deaf individuals. It's likely that the use of generalized models and comparison of productions to these models enable the learner to develop a pattern of his/her own that is similar, but not identical, to that used to produce the model. This view is supported by Fletcher, Dagenis, & Critz-Crosby's (1991) who examined gains associated with speech teaching using the EPG. Recall that the EPG utilizes sensors that monitor the amount of contact between the tongue and various portions of the palate. Fletcher, et al. (1991) found that the largest gains were found in children using the EPG for speech learning when their productions were grossly different than normal. When

their productions were close approximations prior to therapy, gains were often minimal. This suggests that the feedback based on generalized standards may not be adequate for refinement required to improve close approximations to the correct production.

Comparisons. In many cases, computerized devices are involved primarily with displaying a target and an attempt, and the teacher or user must evaluate the similarity or differences between them (for example, the Palatometer™ and Visipitch™). The teacher thus plays an important role by both evaluating the closeness of the attempt to the standard, and by providing an explanation of what should be done to more closely approximate the target.

A few devices are able to compare the speaker's attempt to a standard and provide a proximity metric. These devices typically give the learner a proximity score (or graphic display based on this score) reflecting the extent of match between the attempt and target. Examples of devices capable of such comparisons are the ISTRA system (Watson, et al, 1989), the Speechviewer II™, and the Video Voice™.

Most devices capable of providing proximity scores based on automatic comparisons of attempts and targets provide the learner with knowledge of results. To date, no devices have been reported that provide knowledge of performance by automatically evaluating attempts and comparing those attempts to a standard. This is somewhat understandable since the task of discerning the elements of signals that are important for production, and those that are not, may be a difficult one. For example, in using the EPG, it may not be clear from subject to subject which electrodes must be contacted for articulation of a particular sequence and which electrodes are not essential for accurate production (Fletcher, Dagenis & Critz-Crosby, 1991).

4. Tactile feedback.

Much of the discussion thus far has focused on devices that provide visual displays of models, speech attempts and feedback. Alternatively, tactile devices have been used to facilitate speech development. Systematic exploration of tactile sensation for speech reception began with the pioneering work of Gault (1924). Since that time various approaches have been explored for transforming and encoding speech for tactile

presentation. Devices have been developed and studied that use single channel (Carney, 1988) or multichannel (Friel-Patti & Roeser, 1983) stimulation, vibrotactile (Geers, 1986) or electrotactile (Lynch, Eilers, Oller & LaVoie, 1988) stimulation, and that present the skin with information about the speech spectra (Lynch, et al., 1988) or about selected speech parameters such as fundamental frequency (Boothroyd, 1983; Mahshie, Vari-Alquist, Hilley & Brandt, 1993). Miniaturized electronics have led to development of portable devices that can be worn outside of laboratory settings. As a consequence, all tactile aids are not the same (see Sherrick, 1984 for a review).

In most cases, tactile devices used to teach production were designed primarily as aids to assist in speech reception. Some of these devices have been aimed at providing the child with information about a single speech parameter, such as fundamental frequency (Youdelman, MacEachron, & Behrman, 1988; McGarr, Head, Friedman, Behrman, & Youdelman, 1986). Other tactile devices provide information about the entire speech signal, and are thus potentially useful for facilitating production of specific articulation patterns (for example, Friel-Patti & Roeser, 1983).

5. Summary of pedagogical issues

There are three elements the speech teacher considers when teaching speech skills to deaf children: the task, the cues used to elicit production, and the feedback to be provided. The task selected results from an interaction among the particular skill being taught (determined by current speech abilities, existence of antecedent or prerequisite skills, developmental readiness, etc.), the general step at which the child is performing, (elicit, automate, generalize, and promote linguistic usage), and the level of success achieved by the child at a skill area and step he/she moves from initial attempts to mastery. Production cues are the instruction or demonstration provided to the learner in order to evoke a pattern. Cues can range from being extremely detailed descriptions of what the speaker is to do, to very abstract signals. Feedback refers to the information provided to the child concerning his/her production attempts. Feedback can vary both in timing (immediate vs. delayed, concurrent vs. terminal, accumulated vs. separated), and nature (knowledge of performance vs. knowledge of results). Furthermore, feedback can be presented either visually or tactually. While task, cues and feedback are designated for every aspect of speech teaching, they are interrelated and dependent upon each other.

The majority of existing sensory aids used for speech teaching appear to be most useful for teaching automaticity and generalization of productions. Additionally, many of the most popular computer-based speech teaching systems offer activities directed at vocal gymnastics -- altering pitch, loudness or duration of voicing. Consonant and vowel production activities typically provide feedback about the proximity of the attempted production to a target (knowledge of results). A few devices, relying primarily on physiological feedback obtained from aerodynamic or physiologic transducers, are also able to provide feedback about consonants and vowels in the form of knowledge of performance.

Because computer-based devices can potentially be used independently and often motivate children to work on speech activities, they are in many ways optimal for automaticity training, which requires significant amounts of drill and practice. While there are some devices that can aid in eliciting productions, they are not as commonly used, and often require use of sensors able to detect physiological, rather than acoustic signals. No devices are currently available that are optimal for facilitating linguistic usage. While experimental systems have been developed that permit clinicians to control cue and feedback parameters during instruction, only limited manipulation of these parameters is possible with popular technologies that are currently available in the marketplace.

3. The Ultimate question: Do technologies work?

   1. Framework for viewing efficacy literature

The previous section examined the extent that existing MM&T support and expand current speech teaching practice. Perhaps the most significant questions impacting on the value of existing technologies and the needs for future technologies are those relating to the effectiveness and usefulness of existing devices in improving speech skills. While numerous devices have been developed to assist deaf children learning to speak, there is a significant lack of research examining the effectiveness and usefulness of these devices (for example, Bernstein, Goldstein & Mahshie, 1988; Bernstein, 1989; Watson & Kewley-Port, 1989). Nonetheless, there is a body of literature emerging that examines the effectiveness of various speech teaching technologies. That literature forms the basis for the current synthesis.

Assessment of systems and devices typically involves two, somewhat distinct types of evaluations, formative and summative (Dick & Carey, 1990). Formative evaluations are designed to establish both how well the system does what it purports to do, and how easily the end-user(s) are able to use the features built into the system. Summative evaluations, on the other hand, examine how effective the system is in promoting accurate speech production. Each of these types of evaluation will be discussed below.

1. Formative evaluation: reliability

Formative Evaluation. Formative evaluations of speech training aids are typically designed to address two questions: i. How accurately does the device do what it's supposed to do?, and ii. How acceptable and desirable is the device to clinicians and children?

Accuracy. As suggested above, computer-based devices for speech teaching not only provide models and cues, but must also accurately and reliably present feedback. This latter aspect is particularly important in systems that provide criterion based feedback of results, since the feedback must be consistent from trial to trial and also correspond closely with clinician's perceptions.

Evaluation of the accuracy of speech training devices, and calibration of such device decisions against clinician perceptions, has been limited. The ISTRA system uses speaker dependent speech recognition technology to permit practice and drill of syllables and sentences (Watson, Reed, Kewley-Port, & Maki, 1989). Several evaluations were conducted to determine how well the speech recognition system would substitute for human judgements on the goodness of articulation of whole words. Five clinicians rated the overall accuracy of a series of words produced by two normal-hearing speakers who intentionally varied the intelligibility of their utterances. The judges rated the overall articulatory goodness of the utterances using a six point scale. The three productions of each utterance that were perceived by the listeners as most intelligible were subsequently used to generate a template for the computer-based recognizer. The computer-based recognizer was then used to evaluate the proximity of each utterance to the template. Correlational analyses of these data indicated that the experienced human listeners judgments were in somewhat greater agreement about the

intelligibility of these utterances than were the computer-based judgments, but the computer judgements were in general agreement with the human jurors.

A basic requirement of a speech teaching device is that it provide reliable feedback; the feedback must be consistent for similar attempts at a production. To establish their system's reliability, Watson, et al. (1989) had judges listen to and score twice a series of recorded utterances produced by a deaf speaker. Additionally, the utterances were twice scored by the computer-based system. Results showed that the device was considerably more consistent than were clinicians in rating the same utterances twice. This is understandable since the computer-based system would not be susceptible to varying criteria, speaker familiarity, or other factors that might affect the human judge's reliability.

These findings suggest that this computer-based system provided a reasonable substitute for human judgements of acceptability, and somewhat more reliable judgments than those obtained from human judges. This latter point is important for demonstrating the potential utility of a device to be used for independent drill, since inconsistent, unreliable responses are clearly undesirable in a device designed to provide feedback during independent practice of speech skills.

2. Formative evaluation: human factors

Clinical acceptability. Often device development results from an engineering solution looking for a problem rather than from the needs of clinicians and students. For this reason, it is extremely important that end-user input be a part of the development, and that reaction of end users be evaluated. Devices that are complex to operate and calibrate, that fail to address skills that are clinically important, or that fail to grade tasks and cues adequately, are not likely to be used.

Mahshie, et al. (1988) examined a number of human factors issues for the Hopkins speech training device by having two clinicians keep records during an extended period of trial clinical use. The device was part of a larger project to develop two related computer-based systems, one for use in a clinical setting and the other for drill and practice at home. This approach to evaluating human factors revealed a number of features of the system relating to ease of use, reliability, children's reactions to the device, and perceived clinical benefit.

An alternate approach was used to evaluate the acceptability of a system developed at Gallaudet University that provided the learner with feedback derived from aerodynamic sensors (Mahshie, Wilson-Favors, Schneider & Brandt, 1991). The system (the Gallaudet University Speech Training and Evaluation System or GUSTES) was placed at a school for deaf children where teachers and children used the system during therapy. Following a brief evaluation period, a focus group was convened and the teachers were asked a series of questions aimed at evaluating such factors as user friendliness, value of feedback provided, children's reactions to using the device, etc. Many of the recommendations served as the basis for subsequent changes to the system.

Kewley-Port & Watson (1991) point out the importance of these types of formative evaluations, but stress that they are not substitutes for substantive evaluation of clinical effectiveness. Summative evaluations of clinical efficacy constitute a different type of device evaluation.

3. Summative evaluation

Summative evaluation. Summative evaluation studies are directed at the central question of how effective the devices are for teaching speech to deaf children. This, of course, is the ultimate question that needs to be addressed for all systems. In general, efficacy experiments examine the clinical value of speech teaching devices by either comparing the progress made with the device to progress associated with alternate intervention methods, or by examining changes that occur as a consequence of intervention (Watson & Kewley-Port, 1989).

While questions of clinical efficacy are most important, few systems currently on the market have undergone rigorous evaluation of clinical effectiveness. For example, Watson & Kewley-Port (1989) reported that only 5% to 10% of the commercially available or prototype computer-based speech teaching systems that have been reported in the literature have been tested in controlled experiments.

Below is a brief description of speech teaching technologies whose clinical efficacy has been reported. While other systems and devices exist, the limited data available concerning their clinical benefit makes it difficult (if not impossible) to ascertain their clinical value. Descriptions of the efficacy of physiologically based, and acoustically

based devices are given separately below, followed by a brief description of the efficacy of tactile devices for speech teaching.

2. Efficacy of Acoustically-based Computer-based Speech Training devices

The vast majority of Computer-based speech training (CBST) devices rely on feedback obtained from a microphone. One of the first computer-based speech training systems (Nickerson, Kalikow & Stevens, 1976) employed a PDP-8E laboratory computer system, and utilized a voice microphone, and accelerometers on the throat and nose. The system provided 4 different types of visual displays to teach production of various timing, pitch, voice quality and articulation skills .

To examine system efficacy, forty two orally educated deaf students between 8 and 18 years of age (mean = 11) used the system in conjunction with a series of speech tutorials (Boothroyd, Archambault, Adams, and Storm, 1975). Each child received between 11 and 96 tutorial sessions.

The students using the device showed gains in isolated speech skills and in rehearsed speech, with the most improvements observed in production of suprasegmentals. Boothroyd, et al. (1975) concluded that "... the system, as evaluated, lent itself to work on suprasegmentals rather than articulatory features. Moreover, (while) it was relatively easy for students to use the display for the acquisition of vocal gymnastics skills and the improvement of rehearsed voice... less than half of (the children) showed significant generalization to unrehearsed or spontaneous speech". (p 189). The investigators suggested, however, that the limited carry-over observed was likely because the device was used for only a limited number of sessions and there was little focus during the therapy sessions on generalization to spontaneous speech.

The limited testing of devices is a significant consideration is evaluating the efficacy of devices. Arends, et al. (1991) evaluated the efficacy of a device (the Visual Speech Apparatus or VSA) developed in Holland that provides visual feedback of various speech parameters. They examined changes during an entire school year by comparing gains in performance by an experimental group (receiving instruction using the VSA) and a control group (receiving traditional therapy).

Among other evidence of gains associated with use of the VSA, Arends et al. (1991) observed significant improvements in skills associated with extended use of the

device.[6] Moreover, these differences between traditional and VSA based training were not observed in performance evaluated at the middle of the academic year following a more limited use of the VSA. While these results were promising, most of the gains observed, like those reported by Boothroyd, et al. (1975) were in isolated and rehearsed speech, particularly suprasegmentals.

The IBM SpeechViewer™[7] is perhaps one of the most popular commercial devices currently available[8]. This device, relying on a microphone signal, offers games and activities for facilitating awareness, "skill-building" and patterning of selected speech features, including intensity and fundamental frequency control, and vowel contrasting. There are also a number of graphic displays that present acoustic parameters against time.

Despite its' popularity in schools and clinics, there is only limited research evaluating the clinical efficacy of the SpeechViewer™. One study, conducted by Öster (1989), involved teaching two Swedish deaf children to alter consonant duration (Child I) and plosive consonant voicing (Child II) using the device. Gains were observed in association with teaching these two skills using the SpeechViewer™. Öster suggested that the primary benefit offered by this device derived from its' ability to provide the learner with "objective, meaningful, non-verbal" feedback.

More recently Pratt, Heintzelman & Deming (1993) explored the efficacy of the IBM SpeechViewer's™ Vowel Accuracy Module for the treatment of vowel production. They examined the extent of progress made by six deaf children who used the device for a four month period to learn production of the vowels /i/ /a/ and/u/. They found that the device did promote more accurate production, but noted that a number of difficulties were encountered, including inaccuracies in the feedback provided by certain voice qualities and pitches, inability to sustain the children's interest, and non-linearity in the criterion adjustment control."

As noted above, computer-based devices are particularly appealing because they can be used for unsupervised speech training. Boothroyd, et al. (1975) saw this potential nearly 20 years ago, but expressed two concerns: 1. a lack of adequate graded drill and practice activities and 2. the tendency for children to develop bad speech

habits that are related to skills for which the computer does not provide feedback. These same concerns continue today with current technologies.

Only limited research has examined the use of speech training devices in the home. The Johns Hopkins Speech Training Aid (Mahshie, et al, 1988) was comprised of two systems one designed for use in the clinic (the Speech Training System or STS), and the other designed for use in the home (the Speech Practice System or SPS). The STS was comprised of both physiological and acoustical transducers while the SPS used only acoustic signals (Ferguson, et al., 1988).

To evaluate the SPS, it was placed in the homes of five profoundly deaf children for a one to two week period. The children used the device for an average of 8 to 25 minutes each day, usually under the supervision of a parent or sibling. Parents kept detailed logs of the amount of time their children used the device, as well as observations about interest, ease of operation, and overall reaction to the system. The parents reported that the device was used with interest by the children, and that the activities and games seemed appropriate. Clearly the most significant outcomes of this preliminary evaluation was the increased practice the device permitted outside the therapy room. In addition, having the device served as a focal point for speech activity.

An alternate approach to independent drill and practice was employed in the ISTRA system (Kewley-Port, Watson, Maki & Reed, 1987). ISTRA uses a speaker-dependent speech recognition board in which productions are compared to a stored template, and a proximity metric is generated. The developers suggest using the students best production as the standard used to evaluate accuracy. This approach is somewhat different from others because analytical work involved in teaching particular articulatory patterns is left to the clinician, while enabling the learner to drill and practice independent of the teacher. Thus the targets for speech teaching are syllables, words or phrases that the child has produced adequately (at least a few times). The primary virtue is that the system enables the learner to develop automaticity by providing directed and monitored feedback that appears valid and reliable.

Limited evaluation of the clinical value of the ISTRA has been reported, in which three children (2 deaf, one normal-hearing) were studied during a series of tutorial sessions in which ISTRA was used to mediate speech drill. The authors concluded that

" there is evidence that the changes that occurred in production and generalization of speech sounds can be directly attributed to the treatment provided and not extraneous variables". (p. 36)

3. Efficacy of physiologically-based CBST devices

It was suggested above that earlier stages of speech teaching are aimed at providing the learner with an awareness of how to control the articulatory gestures for production of a particular speech pattern. It would thus seem that providing direct, physiologically relevant feedback would be most optimal for earlier stages of teaching speech skills. Accordingly, a number of devices and systems have been developed and evaluated that provide feedback obtained from physiological sensors, and that provide models and cues about appropriate patterns to be achieved.

The electropalatograph (EPG) has been used to teach certain aspects of articulation to deaf individuals (Fletcher & Hasegawa, 1983; Fletcher et al., 1991). The EPG is a computer-based physiological monitoring system that provides visual information about tongue and palate contact during speech. The results of the earliest training study (Fletcher, Hasegawa, McCutcheon, and Gillion 1979) showed significant improvement in a deaf adult's production of /s ʃ t k/ in conjunction with training using the EPG. Two noteworthy aspects of the study were that the improvements were also observed in segments not actually trained (a cross-over effect) and improvements were maintained for ten months following teaching using the device. Fletcher, et al. (1991) further explored the benefit of teaching lingual consonants (/t d k g s z ʃ /) to five profoundly deaf children (ages 10 to 16) using electropalatography. They examined both change toward contacting critical electrodes (those considered essential for production), and listener-perceived changes in the CV syllables. The children were seen twice a week for four weeks, during which they drilled CV syllables containing the target consonants in /i/ and /a/ contexts. Statistically significant improvements following training were observed in the perceived accuracy of target segments for all children. Four subjects showed significant perceived improvements in the majority of segments attempted, while all of the children demonstrated some improvement in contact of critical areas of the palatal region for articulation of the target segments.

Fletcher, et al. (1991) noted that the gains associated with EPG use were particularly remarkable because the children had not been able to improve production of these segments despite significant period of speech therapy during their lives. They concluded that physiologically based visual displays can be of benefit.

It was earlier noted that Fletcher et al. (1991) found that the greatest gains were observed in students whose productions were grossly different than normal. It would appear that the primary benefit of the feedback provided by the EPG (and possibly other physiologically-based feedback devices) is in facilitating awareness of articulation. Thus these devices are probably most beneficial during earlier stages of speech learning because they provide the learner with a generalized pattern of what is to be achieved, and feedback about how well they have attained that goal.

The pneumotachograph (PTG) is a somewhat less invasive device that provides information about articulatory gestures (Mahshie, Herbert & Hasegawa, 1984). The PTG has been used in the laboratory to examine oral and nasal airflow patterns associated with production of various segments. Such patterns can provide useful information about the manner of production and voicing categories of consonant segments. Since aerodynamic patterns result from an ensemble of articulatory effects, the absolute articulatory patterns used (such as the precise placement of the articulators) becomes less important than production of the overall aerodynamic pattern required of a particular segment or sequence. It has also been suggested that the aerodynamic properties of the vocal tract represent significant speech goals (Abbs, 1986). Visual displays of aerodynamic targets and feedback would thus seem potentially useful for both practical, and theoretical reasons.

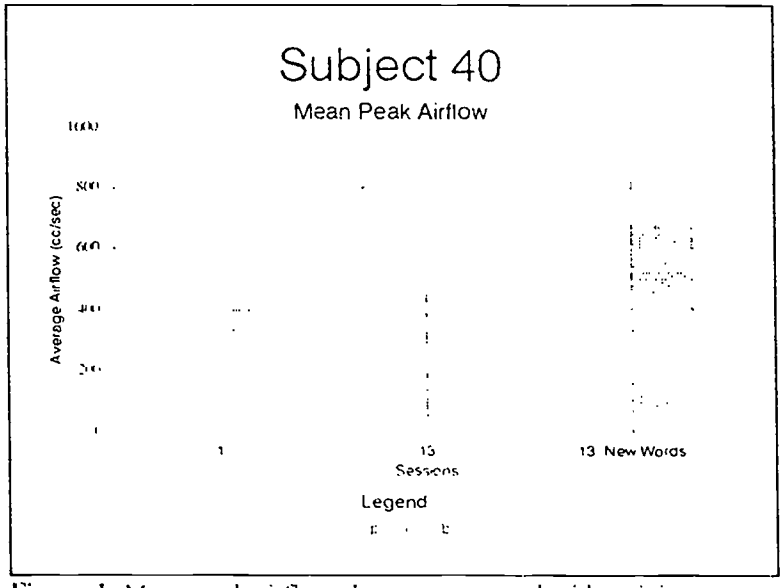

Figure 1. Mean peak airflow changes associated with training a young deaf adult to modify plosive consonant voicing using airflow feedback. Hearing speakers produce /p/ with greater than 600 cc/sec, and /b/ with less than 200 cc/sec mean peak airflow

To examine the clinical value of the PTG, a visual display of the airflow signal was used to teach accurate consonant voicing to two deaf adults (Mahshie, Herbert & Hasegawa, 1984; Mahshie, 1987) As shown in Figure 1, subject 40 showed more normal aerodynamic patterns in conjunction with training using the PTG (Mahshie, Herbert & Hasegawa, 1984). In addition (and more importantly), listeners perceived notable improvements in consonant voicing accuracy in conjunction with training using the device (Mahshie, 1987) (See figure 2). While results were encouraging, the system was not designed for use with young children; nor was it practical to replicate the system for use outside of the laboratory.

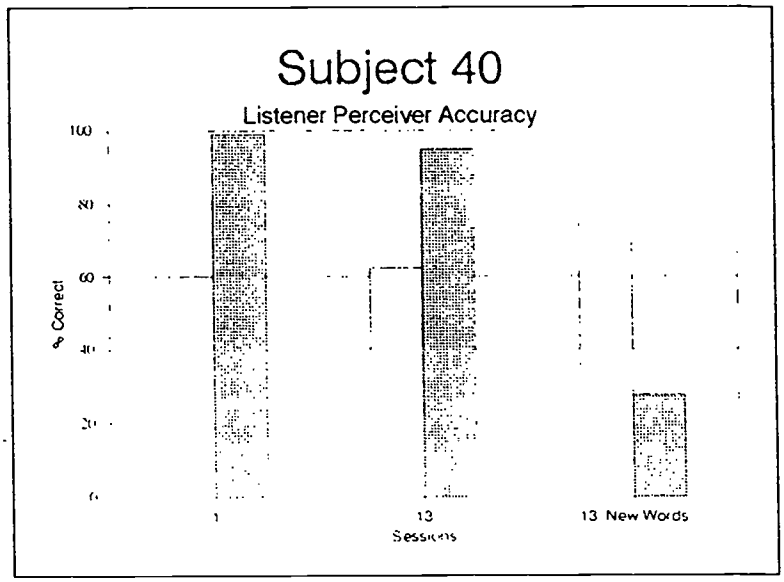

Figure 2. Listener perceived accuracy associated with training described in figure 1.

A second generation system was subsequently developed. The system is called GUSTES (Mahshie & Yadav, 1990) and provides feedback of aerodynamic and limited kinematic speech parameters obtained from oral airflow, nasal airflow, oral air pressure, electroglottograph and accelerometer signals. This PC-based system permits easy selection and storage of templates, multiparameter display, and other features that made it more optimal for use with children.

Efficacy of the device was examined through a series of multiple baseline, single subject studies involving four profoundly deaf children (Mahshie, Wilson-Favors, Schneider & Brandt, 1990). The children, age 11;8 to 12;5, were taught to produce one or two consonant segments that were error productions prior to teaching. The device was used to present targets, and to display the aerodynamic patterns associated with each trial.

Results showed that the children using the training system made appreciable gains in production of the target segments in the words that were trained, and that the skill generalized to correct production of these segments in words not trained. (see figure 3). The rate of improvement varied for different children and for different segments and contexts. One of the encouraging findings of this work was that correct production of the target segments was generalized to new words without specific generalization teaching for three of the four children. The remaining child required a brief period of teaching about how to use the newly acquired articulatory skill before generalization was observed.

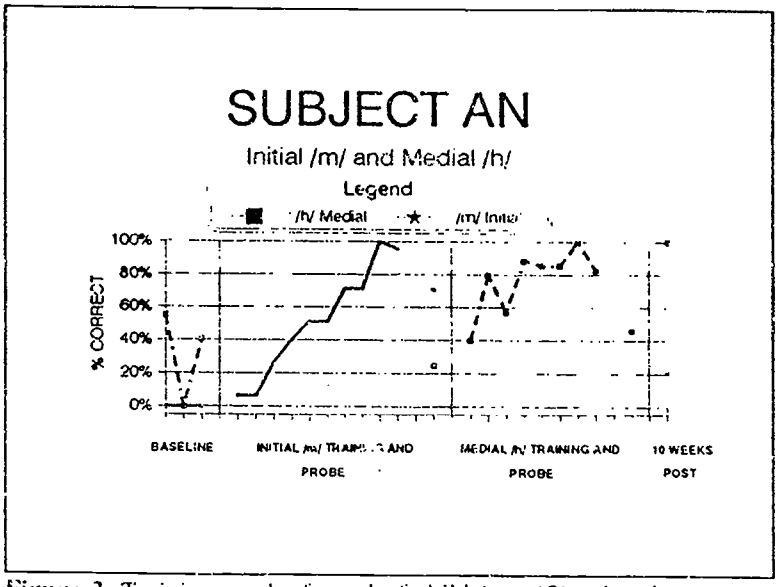

Figure 3. Training results for a deaf child (age 12) using the GUSTES system. Given is the percentage correct (based on listeners' judgments) for production of initial /m/ and medial /h/. Data is shown for baseline sessions, training sessions, probes, and post-training sessions. Different stimuli sets were used for training sessions than for baseline, probe and post-training sessions.

Ten weeks following cessation of training with the device three of the children demonstrated improved production accuracy for all sounds/segments trained. The remaining child demonstrated improved performance for only one of the two segments trained.

These limited studies point to the potential usefulness of physiologically based feedback for teaching speech skills to deaf individuals. Both significant improvements and notable carry-over have been observed. However, existing devices do not enable the teacher to control many of the pedagogical features that were discussed above. Although feedback of actual articulatory patterns is likely beneficial for effectively eliciting production patterns, it may not be optimal for all stages of skill learning. Thus these learning patterns may represent minimal, rather than optimal gains associated with such feedback.

4. Efficacy of Tactile displays for speech teaching

The majority of studies examining the impact that tactile devices have on speech learning have addressed the long term effects of tactile aid use on children's speech production (for example, Proctor and Goldstein, 1983). In most cases, wear-time is for circumscribed periods of each day, most often during speech therapy, and the devices are used as prostheses for speech reception. For example, Oller, Eilers, Vergara and LaVoie, (1986) looked at speech reception and production of 13 hearing impaired children who wore multichannel tactile devices (the Teletactor or Oregon Vocorder) for approximately 70 hours distributed over approximately 200 sessions in a four month period. They found gains in speech production and reception associated with the period of aid use, although there were considerable differences among their subjects.

Proctor and Goldstein (1983) looked at a hearing impaired child's receptive vocabulary acquisition associated with 10 months of training using a single channel vibrotactile aid. While the total amount of wear-time was not reported, their findings revealed that the most rapid increase in vocabulary development occurred after 3 to 4 months of aid use. More recently Geers (1986) replicated this study with a second hearing impaired child and obtained similar results.

Friel-Patti and Roeser (1983) attempted to look at broader aspects of communication associated with aid use. They studied 4 children who wore a multichannel device (the SRA-10 multichannel device) for approximately 10 - 11 hours per week over a 3 to 4 month period. They evaluated various general and structural characteristics of the children's signed and spoken communication. The researchers concluded that the children exhibited improved communication skills during the period the aid was being used, while there was a decrease in these skills during the period the aids were not used.

Few studies have attempted to compare the use of sensory aids to other approaches for teaching a particular speech skill. Inherent in such comparisons is the need to attend to instruction as a significant variable, and hence to address some of the pedagogical issues discussed earlier. One such comparison was initiated at the Lexington School for the Deaf in which the relative merit of auditory, visual and tactile feedback of fundamental frequency for teaching fundamental frequency control was examined (McGarr, Youdelman & Head, 1989; Youdelman, MacCeachron & McGarr, 1989, McGarr, Head, Friedman, Behrman & Youdelman, 1988). A similar curriculum was used to teach fundamental frequency control to four groups of children: a control group receiving traditional therapy,

a group receiving auditory only feedback, a group receiving visual feedback from the Visipitch™ and a group receiving tactile feedback from an 8-channel vibrotactile aid. Their findings indicated that the children whose speech lessons included a sensory aid showed significantly greater gains than did the children who received traditional therapy. In addition, the visual display appeared more effective for teach appropriate average pitch, while the tactile display was particularly helpful for teaching dynamic intonation patterns. These findings are supported by research by Mahshie, Vari-Alquist & Hilley (1993).

While tactile aids appear useful for teaching some speech skills, it's clear that there are significant questions that remain concerning when they are the most optimal source of feedback. Additional research is needed to examine both optimal sensory modalities for different tasks, learner attributes that might suggest the merit of one modality over another, and the relative value of using combined sensory modalities for teaching various speech skills.

4. General summary and conclusions re. state of the art of MM&T for teaching speech to deaf children.

1. Summary of MM&T for teaching speech to deaf and hard-of-hearing children.

It's been suggested here that sensory information plays a key role in speech acquisition by permitting development of models and enabling after-the-fact feedback to mediate speech change. For many deaf children, reliance on limited audition as the primary source of feedback may be inadequate, and alternate sensory information may need to be provided.

Certainly studies examining the overall efficacy of existing devices suggest that their use does contribute to speech improvements. However, only limited comparative studies of intervention using CBST devices and more traditional approaches to speech improvement have been conducted. The question thus remains as to whether devices are an improvement over more traditional approaches for speech improvement.

In addition to providing the learner with information about his/her own speech, it is also important to consider the way in which the sensory information is used in speech teaching. Current devices permit teaching of a somewhat limited range of skills and offer clinicians less than optimal control of important cue and feedback parameters. There is thus a less than optimal match between the functionality of devices in

development or in the market place, and sound speech teaching principles. These deficiencies need to be addressed in subsequent devices.

While consideration of pedagogical factors is needed, devices as they currently exist can clearly help speech teaching. As noted earlier, there is a trend in many schools and programs in the U.S. toward reduced resources directed at speech development. Reduced time available for speech development activities requires that speech teaching be as efficient as possible. A particular promising aspect of CBST devices is their potential use for independent drill and practice. As devices become more reliable and easier to use, they can prove useful as extensions of speech teaching classes.

While home use continues to be an important aim of these devices, consideration of the inherent limits of computer-based feedback must be considered and safeguards taken to limit development of inappropriate speech behaviors resulting from extensive drill and practice of incorrect patterns not monitored by the device.

The efficacy of tactile sensory devices for teaching prosodic speech skills has been studied, and the results suggest that such displays can be most beneficial for teaching certain dynamic aspects of speech production (such as production of intonation patterns). An additional benefit of tactile devices resides in their ability to be worn, and thus to serve as a prosthesis or outside of therapy room aid to speech monitoring. As additional wearable devices are developed, this aspect of their use needs to be examined considered and examined.

2. Status, Suggestions and guidelines for future development and evaluation of MM&T.

This synthesis has described a number of factors inherent in teaching speech skills to deaf children, and has examined various MM&T that have been developed to facilitate speech learning. Given below are a series of statements that characterize the current "state of the art" of speech teaching for deaf and hard-of-hearing children. Following each status statement is a suggestion for addressing perceived needs.

Status statement 1: The existing speech teaching model used most extensively (Ling, 1976) has value but has not been well evaluated or updated to include current understanding of speech development.

Suggestion: The existing curricular texts, media, and supportive materials need revision to incorporate our current understanding of normal speech acquisition and speech learning by deaf children.

Status statement 2: The current, documented approaches to speech teaching make certain assumptions about the setting, amount of effort to be put forth for speech teaching, etc. While there are other approaches (and modifications of the Ling approach) employed in different settings, they are not well documented.

Suggestion: Alternative or modified approaches to speech teaching, particularly those that are based on more synthetic, top-down, language-based teaching strategies, need to be described and curriculum based on such strategies developed.

Status statement 3: Existing devices are primarily developed to provide a visual (or tactile) display of speech or a speech parameter (such as the degree of contact between the tongue and roof of the mouth). Yet there are a number of instructional parameters that clinicians normally manipulate in teaching speech (such as the nature of cues or timing of feedback) that are either not available, or are limited, in current technologies. A major premise of this synthesis has been that devices should permit clinicians to continue to adapt the important parameters of speech teaching to the changing level of mastery of the student. Device use should not result in suspension of concern about these normally important issues.

Suggestion: Control of various pedagogical parameters need to be built into future devices (see 4,5,6 and 7 for specific suggestions).

Status statement 4: Current technologies focus primarily on earlier teaching goals (suprasegmentals and vowel production) or on earlier levels of skill teaching, (elicitation, automation, and some degree of generalization). Little exists that is aimed at facilitating production of consonants, or promoting linguistic use. This is somewhat at odds with the needs of speech instruction models in which the primary focus of speech work is language-based.

Suggestion: Speech teaching devices are needed that focus on consonant production, and facilitation of linguistic use.

Status statement 5: While the degree of cue grading possible with a device likely has a significant impact on the eventual carryover of skills taught, devices are extremely limited in the amount of cue grading possible.

Suggestion: Greater flexibility in presentation of cues is needed for existing and future systems.

Status statement 6: While provision of feedback is the primary feature of many devices, there are considerable limitations concerning the timing and nature of feedback provided by any one device.

Suggestion: Greater flexibility in controlling feedback parameters is needed for existing and future systems.

Status statement 7: The use of tactile feedback has been demonstrated to be useful, but it's not clear for which skills it is most beneficial.

Suggestion: Basic, formative evaluations of these devices are needed to establish speech skill areas for which such feedback is best suited.

Status statement 8: The value of different kinds of feedback (knowledge of performance or knowledge of results) has been shown to be significant for other kinds of motor learning. The role that the kind of feedback provided to the learner has on speech learning has not been adequately evaluated.

Suggestion: Basic research on the value of different forms of feedback is needed, and the findings of such research needs to be incorporated in devices.

Status statement 9: Despite the obvious importance of evaluative research, there are only limited studies examining the most commonly used commercially-available devices. In particular, studies of the clinical efficacy of these devices are needed.

Suggestion: Efficacy studies need to be conducted and reported on existing devices.

Status statement 10: No single device currently available appears to have optimal features for speech teaching. However, existing efficacy studies are typically device based rather than student based. That is, the efficacy of an optimal program of instruction using combinations of existing technologies has not yet been evaluated.

Suggestion: Efficacy studies that are child-centered rather than device-centered are needed to establish the real effectiveness of existing technologies.

Status statement 11: While limited research suggests that tactile feedback may be more beneficial for learning some speech skills, and visual feedback more beneficial for learning other skills, there is a significant lack of understanding of which skills can be best taught through which form of feedback.

Suggestion: Research is needed examining optimal feedback modalities for teaching various speech parameters.

Endnotes

1. While recognizing the important role that language plays in this process, the discussion here will focus on the more limited area of speech development.

2. Even with this degree of focus and effort, not every child enrolled in an oral educational program will develop intelligible speech

3. It will later be suggested that there are few resources available for more top-down approaches to teaching speech, and that there is a need to examine the efficacy of such instruction in terms of its impact on language development, and speech learning.

4. No existing system is able to provide simple and easily interpreted feedback during connected speech.

5. Clinicians often vary feedback timing by manipulating the display screen--turning the screen away from the student or asking the child to close his/her eyes is often the easiest way of controlling he delay between the production and presentation of feedback.

6. It will later be pointed out that an important consideration in comparing computer-based and conventional speech teaching procedures is that instruction be developed that permits comparison by being able to be implemented using both approaches. This was not addressed in this study.

7. While the most recent version of this device is the SpeechViewer II™, to the author's knowledge there is no published research on its efficacy.

8. Sales figures for the SpeechViewer are unavailable from IBM.

9. This study was conducted using the predecessor of the current, IBM SpeechViewer II™ device. The current system may have addressed some of the difficulties encountered in this study (for example, more varied activities are available that might maintain children's interest).

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Appendix A

Journals Examined for Present Synthesis

American Annals of the Deaf

Clinical Linguistics & Phonetics

Ear and Hearing

Journal of the Acoustical Society of America

Journal of Rehabilitation Research and Development

Journal of Speech and Hearing Disorders

Journal of Speech and Hearing Research

Speech Communication

Volta Review